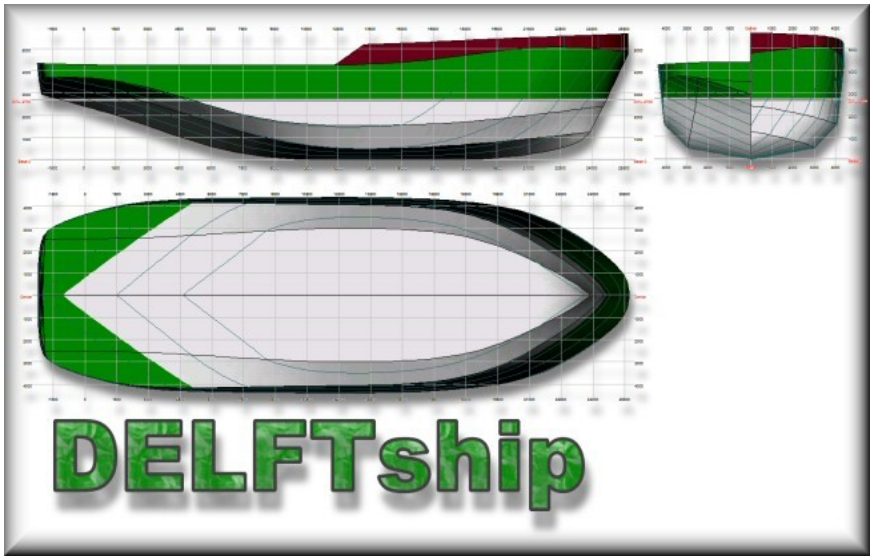

DELFTship™ user manual

Version 3.1

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1. License and copyright

1.1 DELFTship™ program.

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1.2 DELFTship™ user manual

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2. Background to surface modeling

2.1 Surface modeling

DELFTship uses a technique called surface modeling to completely define the outer shape of a ship. This technique involves “sculpting” the hull as if it were a very thin and flexible piece of cloth by pulling and shifting points. It is however not limited to the hull alone as we will see later. Decks, superstructures, masts, keels and rudders can be modeled this way too. The biggest advantage of surface modeling is that the model can be completely and accurately described using only a few points. Illustration 2.1 shows an example of a developable tug that was created with 54 points. Unlike other programs, DELFTship uses subdivision surfaces for this task. Compared to other types of surface definition, subdivision surfaces give the designer more flexibility in designing any desired shape. But when you want to get the most of this technique it is important to have a basic understanding of some of its underlying principles.

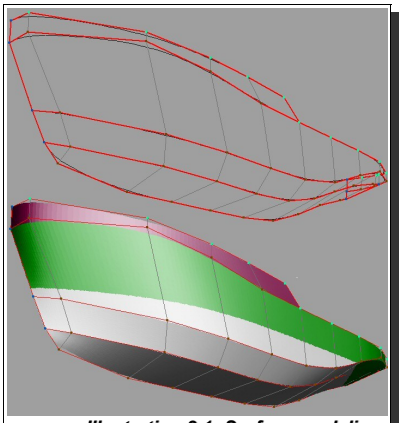


Illustration 2.1: Surface modeling.

2.2 Subdivision surfaces

A subdivision surface is a special type of spline-surface. Normally modeling programs work with parametric spline surfaces like B-Spline surfaces or NURB surfaces. These surfaces are completely described by a set of control points. These are the points which the user can modify to control the shape of the surface. Any point on the surface can be directly calculated from these control points using a set of parametric formulas. The drawback of these parametric surfaces is that they always require a topologically rectangular grid of points. This grid in reality almost always follows the shape of a hull, so it does not look like a true rectangular grid. But it always has say ***N*** points in the longitudinal direction and ***M*** points in the vertical direction where both *N* and *M* might be any number equal to or larger than 2. On illustration 2.3 ***N***=4 and ***M***=4 and the total number of control points equals 4*4=16. With parametric spline surfaces it is not possible to insert a single new point in the surface. Instead an entire row of points have to be inserted as demonstrated on illustration 2.2. This results in having more control points than actually needed or desired, and more control points means more work to the designer. Also very complex shapes cannot be modeled using a single surface. But when using multiple surfaces the designer is challenged with the difficult task of aligning these surfaces at their boundaries. It is often desirable to maintain a smooth transition along these boundaries. Each time one of these surfaces is modified, the adjacent surface has to be modified by the user to maintain this smooth transition.

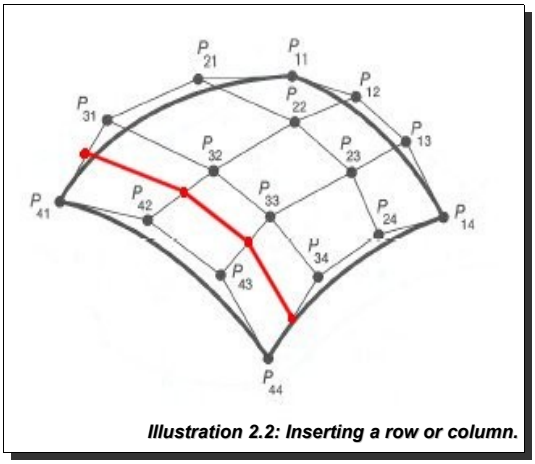


Illustration 2.2: Inserting a row or column.

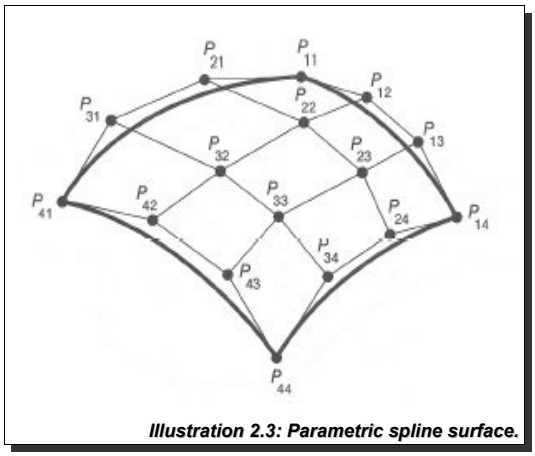


Illustration 2.3: Parametric spline surface.

To overcome these problems DELFTship makes use of subdivision surfaces. Subdivision surfaces also use control points as a modeling handle, just like NURBS or B-Splines and they share the same mathematical background. The main difference however is that the formulas are no longer restricted to rectangular grids of points. The downside is that points on the surface can no longer be directly calculated due to this different approach. Instead the original set of points (called the control mesh) is refined and smoothed in a number of steps. Each step is called a “subdivision step”, hence the name subdivision surfaces. Before explaining in more detail how subdivision actually works it is important to know something about the internal geometry of subdivision surfaces. The surfaces are build from the following three entities:

2.2.1 Points

Points form the basis of the surface. In fact most of the modeling is done by moving points to different locations since this changes the shape of the surface. Additionally, new points may be inserted or existing points can be removed. There are two different types of points:

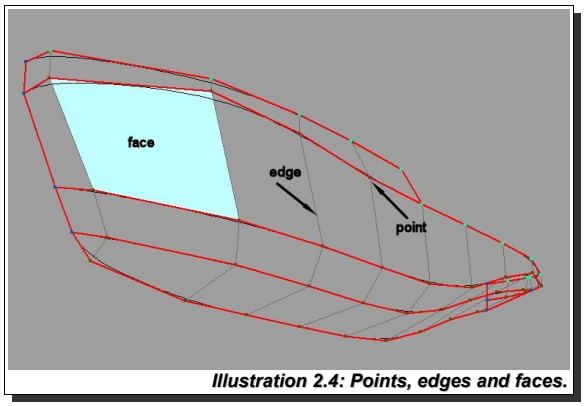


Illustration 2.4: Points, edges and faces.

- *Normal points*. These are all points other then corner points. It is important to realize that these points have a certain offset to the resulting surface. This deviation to the surface is bigger in surface areas with high curvature. It becomes less when more points and edges are inserted.
- *Corner points* are specific points, usually connected to 2 or more crease-edges. Just like a crease-edge can be used to specify that two faces have to be connected in a discontinuous way, corner points may be used to do so with two adjacent edges. Corner points are the only type of points actually located on the hull surface. Points where 3 or more crease-edges meet are automatically set to corner points by the program. By default corner points are displayed blue.

2.2.2 Edges

All points are connected with lines which are called *edges* in subdivision surface terminology. Edges also can be divided into two different kinds:

- *Boundary edges*. These are edges which form, as the name suggests, the boundary of the surface. A boundary edge is characterized by the fact that it has **always** only **1** face attached to it. Examples of boundary edges are the sheer line (when the ship is not fitted with a deck) or the centerline of the ship. The centerline, or profile, is in fact a special case. When defining the hull only its port side is created. So all edges on the center plane are boundary edges as they have only one face connected to it. In reality the ship is symmetric, and when performing calculations DELFTship creates a virtual symmetric ship by mirroring the model in the center plane.
- *Regular edges*. These are all other edges away from the boundary of the surface, and must **always** be shared by **2** adjacent faces. Regular edges are drawn as dark gray lines. The two faces connected to an edge are joined smoothly along their shared edge. It is possible however to mark an edge as a crease-edge. When doing so, the two faces are joined in a tangent-discontinuous way. In other words, crease-edges are used to define knuckle lines. A boundary edge is in fact a specific case of a crease edge since there is no second face to make a smooth transition.

2.2.3 Faces

A face is a little piece of the entire surface (sometimes also called a patch) that is completely surrounded by edges and is usually defined with 4 points. In some areas it is desirable to have less (or even more) points, but generally the best results are obtained when most of the faces consist of 4 points. Faces are divided by edges where the type of edge determines how the faces should be connected to each other.

2.3 Subdivision explained

Now there is a basic understanding of the underlying geometry the process of transforming the control mesh into the final hull surface will be clarified. Illustration 2.5 shows the process of one subdivision step.

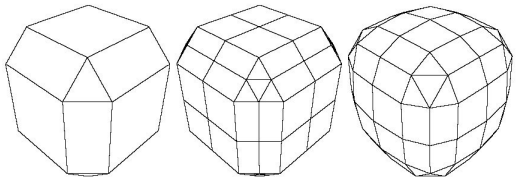


Illustration 2.5: One subdivision step.

- To the left the original control mesh of a beveled cube is visible. The first step in the subdivision process is refining the mesh. This is done by inserting a new point in the middle of each edge (called an edge-point).
- During the second step a point is also inserted at the center of each face (called a face-point) which has more than three points. For faces with three points each new edge-point is connected with the new point of the previous edge, thus creating 4 new triangles. All other faces are subdivided by connecting all surrounding edge-points to the face-point. This way a refined mesh is created which still has the same shape as the original. This process is shown in the middle.
- During the last step all the points in the surface are shifted to a new location in such a way that the refined surface is smoothed. This is called *averaging* in subdivision terms (right side).

If this process of subdividing is repeated a number of times a very fine and smooth mesh is the result. The following illustration shows the same beveled cube after a number of subdivision steps.

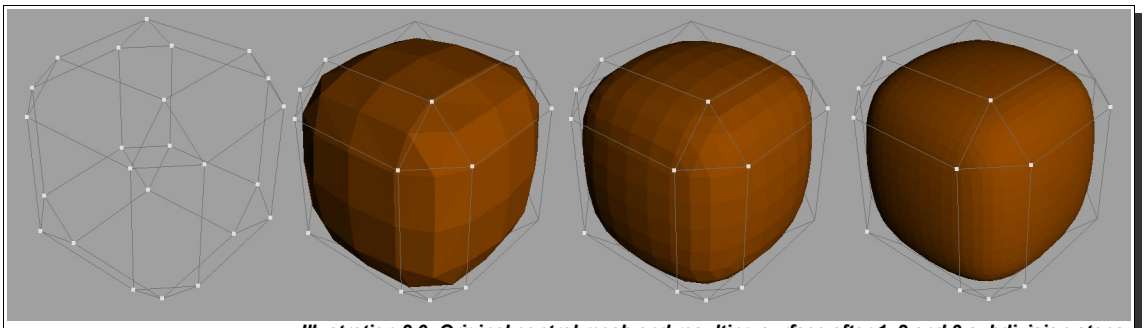


Illustration 2.6: Original control mesh and resulting surface after 1, 2 and 3 subdivision steps.

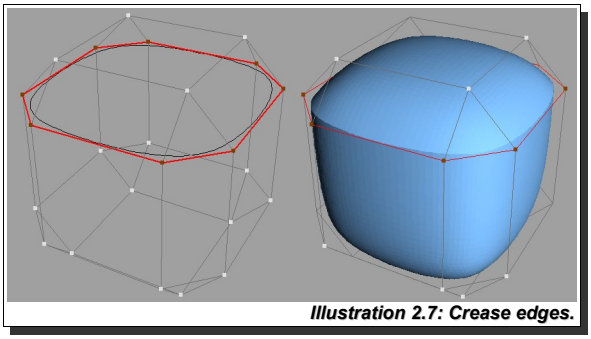


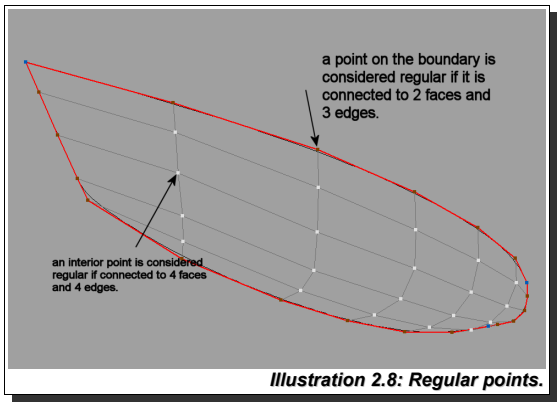
Illustration 2.7: Crease edges.

To the left again the same control mesh is shown, but this time a number of edges have been marked as crease-edges (red lines). The result is a sharp knuckle line going around the cube. It is clearly visible that the faces on both sides of the crease-edges are no longer joined in a smooth manner.

2.4 Guidelines to subdivision modeling

In theory almost any control mesh is valid, however when designing ships the fairness of the resulting surface is of uttermost importance. In this paragraph some guidelines are given to obtain the best results.

- Use a regular grid whenever possible. A grid is considered regular if all faces consist of four points, and all points are connected to four edges and faces. A point on a boundary edge is considered regular if it has 3 edges and two faces connected to it. Of course this is not always possible. Triangular faces may be used as a means to reduce the number of points in an area. 5-sided faces, or 5 different 4-sided faces can be used to increase the number of points. A truly regular grid would look exactly the same as the B-spline surface shown on illustration 2.3.


a point on the boundary is considered regular if it is connected to 2 faces and 3 edges.
an interior point is considered regular if connected to 4 faces and 4 edges.
Illustration 2.8: Regular points.

- Always have **two** faces connected to all edges other than boundary edges. If more than two edges are connected to an edge, that specific edge will be drawn thicker and in a light green color. This must be avoided <u>at all cost</u> as it messes up hydrostatic calculations. boundary edges are allowed, but as soon as they become submerged hydrostatics will not be calculated any more. (see also paragraph 4.3 and paragraph 7.1 for leak points.).
- Make sure that the normals of all the faces point outward (in the direction of the water). This is of uttermost importance since DELFTship calculates hydrostatics by integrating the enclosed volume **at the back** of the faces. If the normal of a face points inward, the volume **outside** the hull would be added to the total volume. By using the actual surface for hydrostatic calculations instead of a number of stations, a higher accuracy is obtained. This is especially true when the model has a heeling angle and/or trim, or is fitted with a superstructure. DELFTship can also check the direction of normals automatically. Automatic checking can be disabled in the project settings dialog as explained in paragraph 4.3.

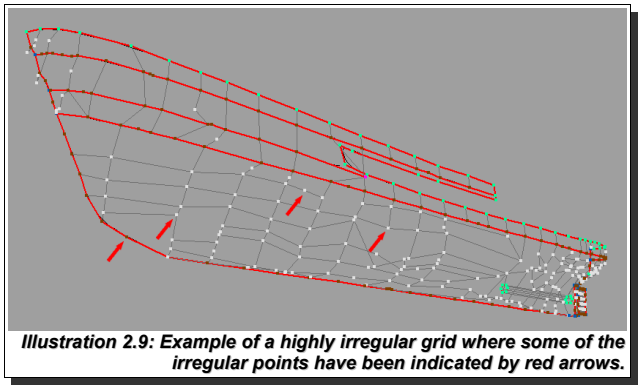


Illustration 2.9: Example of a highly irregular grid where some of the irregular points have been indicated by red arrows.

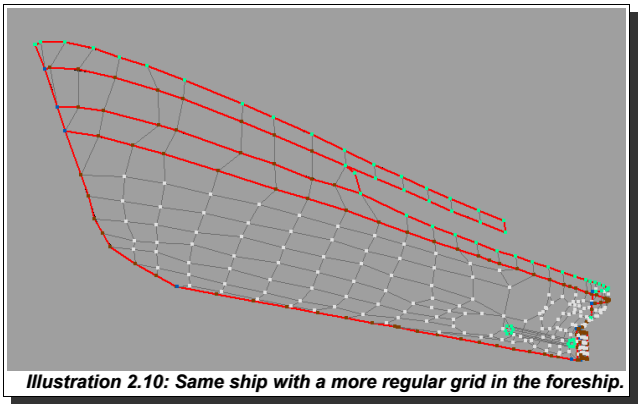


Illustration 2.10: Same ship with a more regular grid in the foreship.

3. Using the hull modeling windows

3.1 Zooming, panning and rotating

When a new model is opened or started the program by default adds 4 windows. Each window has a different view on the 3D hull. The area of the window on which the model is drawn is called a viewport. These viewports also appear in other windows, for example when viewing plate developments. Zooming and panning works the same in all these viewports.

Zooming can be done in four different ways:

- *Ctrl-A* (zoom all)
- Move the mouse up or down while keeping the left button pressed.
- Press *Ctrl-I* or *Ctrl-O*
- Users having a mouse wheel may find it more convenient to zoom in or out using their mouse wheel.

Panning is done by moving the mouse with the right button pressed.

If the viewport displays a perspective view then two scrollbars will be visible also. These can be used to rotate and tilt the model in order to see it from different angles. Another more convenient way to rotate the model is keeping the middle mouse button (or mouse wheel) pressed while dragging the mouse. This also works only in a perspective view.

3.2 Selecting objects

Selecting objects is explained in paragraph 12.1 on page 49.

3.3 Moving points with the mouse

One of the most important options when it comes to surface modeling is dragging points. In order to do this the controlnet must be visible (chapter 6). Although it is possible to select points in a perspective view, the actual dragging of the point can only be done in the bodyplan view, profile view or plan view. When dragging a point all geometrical information is updated real-time. This includes intersection curves, control curves, flowlines and tanks, Especially when the precision of the model is set to a high value this updating might become slow since all hull-related objects have to be recalculated. If it becomes too slow, try using a lower precision. If it is still too slow, switch off some of these objects in your display settings.

3.4 Manually modifying points

If a point is selected, the form displayed to the right is shown, and the position of the point in 3D-space is displayed in it. These values can be altered manually by typing the new location in the appropriate fields. In addition the values can also be altered relatively to the current location by typing the character @ in front of the numerical part. If for example the string @*-0.2* is entered in the field for the y-coordinate, then all the y-coordinates of **all** selected points will be decreased by 0.20. So the y-coordinate for the displayed point becomes 2.10-0.20=1.90. This is a convenient way to shift a number of selected points.

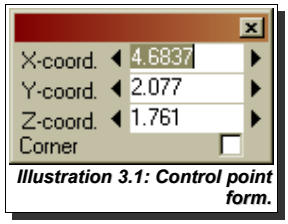


Illustration 3.1: Control point form.

Another way of moving points is by pressing the cursor keys in the bodyplan, profile or plan view. The active point moves a certain distance in the direction of the arrow key that was pressed. This distance, called

"*incremental distance*" is visible on the status bar of the program, next to the amount of undo memory that is in use. By clicking the text displaying the incremental distance a window appears in which a new value for the incremental distance can be specified. Another and faster way is to press either the + or – key. The incremental distance is then changed by 10%.

Finally the black arrows displayed next to each input field on the form can be used to modify the values by the same incremental distance as mentioned above. Illustration 3.2 shows the coordinate system used by DELFTship.

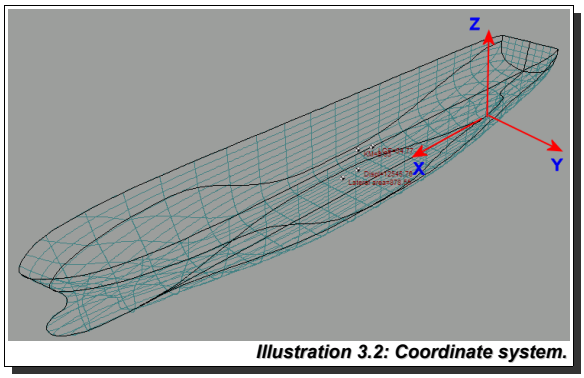


Illustration 3.2: Coordinate system.

3.5 Drawing modes

DELFTship has three different drawing modes which are accessible from the popup-menu under the right mouse button.

- **Wireframe** *(Ctrl-W)*. Only the points, lines and edges are drawn.
- **Shade** *(Ctrl-F)*. The surfaces are drawn in a solid color, lines are drawn on top of it. The submerged part of the surface can optionally be shown in a different color.
- **Developability check** *(Ctrl-D)*. The surfaces are shaded again, only this time areas of the surface that are developable are shaded green while parts that are not developable are shaded red. More about developable surfaces can be found in paragraph 5.8.6 and 11.6
- **Gaussian curvature** *(Ctrl-G)*, used to check the fairness of a surface. The model is shaded in colors, based on the discrete Gaussian curvature in each point. Most hulls are curved in two directions, called the principal curvatures. Gaussian curvature is the product of these two principal curvatures. Now there are 3 possibilities here:

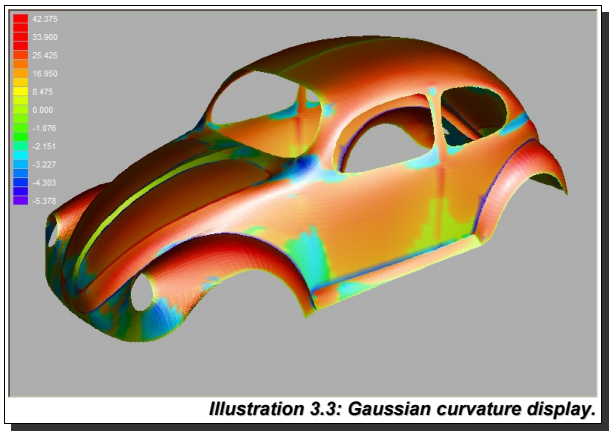


Illustration 3.3: Gaussian curvature display.

  - **Negative Gaussian curvature**. These areas are shaded blue and have the shape of a saddle, since the curvature in one direction is positive while the curvature in the other must be negative.
  - **Zero Gaussian curvature**. At least one of the two principal curvatures is zero, so the surface is either flat or curved in only one direction. In both cases the surface is developable (This is in fact a very important property of developable surfaces). These areas are shaded green.
  - **Positive Gaussian curvature**. The curvature in both directions can be positive or negative, but must have the same sign. These areas are convex or concave and shaded red.

- **Zebra shading** *(Ctrl-E)*. Another option to check the model for fairness. Regions with a constant light-reflection intensity are shaded in bands. This is similar to the way the human eye detects unfair spots on a surface since the shininess and shadows vary in those areas. If the edges of the zebra stripes are curved smoothly then the surface is smooth in these areas. At knuckle lines they vary abruptly.

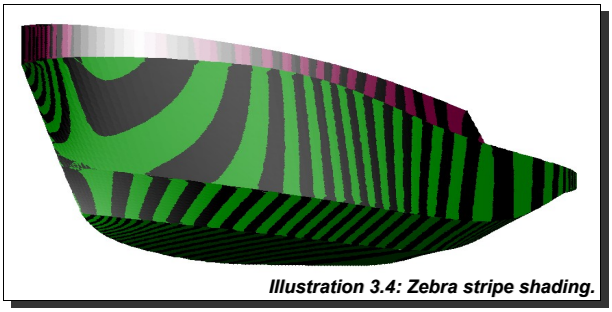


Illustration 3.4: Zebra stripe shading.

3.6 Working with background images

DELFTship has the ability to display images on the background of your model. This functionality is particularly convenient if you have an existing linesplan on paper and want to recreate the lines in DELFTship. You can load a maximum of three images. Each of these images is assigned to a specific view (profile, plan or bodyplan view). You can not assign an image to the perspective view. All options related to background images are located in the pop-up menu that appears when you press the right mouse button in a viewport. When using background images pay special attention to make sure that all horizontal and vertical lines on the images are truly horizontal or vertical.

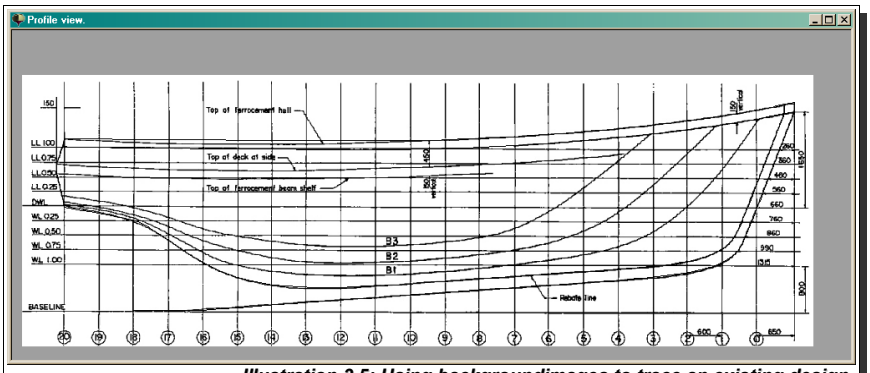


Illustration 3.5: Using backgroundimages to trace an existing design.

3.6.1 Visible

Once you have assigned an image to for example the profile view, it will be shown in all viewports showing the profile view on the model. By changing the *visible* property you can hide the image from a particular viewport.

3.6.2 Clear

The clear command removes the image not only from the current viewport but also from all other viewports displaying the same view. It is entirely removed from the DELFTship model.

3.6.3 Load

Imports a background image. DELFTship only reads *bmp* and *jpg* images. For performance reasons make sure that the images you are going to use are not too big. After having imported an image you must set the origin (paragraph 3.6.5) to make sure it is displayed at the right location. You also have to set the scale of the image (paragraph 3.6.6) to match the size of your model.

3.6.4 Save

Exports the background image to a file.

3.6.5 Origin

If you use this option a special cursor appears and you can drag to image to the correct location by keeping the left button of your mouse pressed.

3.6.6 Set scale

Make sure you set the scale of an imported image before opening another image. DELFTship assigns the same scale of the previously imported image to the freshly imported one. This is particularly useful if you have multiple images imported from the same linesplan. When this option is executed the user is required to click on a point within the actual image of which the location is known. The program uses the same scale for both the horizontal and vertical direction.

3.6.7 Transparent color

Quite often background images are in black and white. Having a huge white area on your viewport can sometimes be distracting. By setting white as the transparent color the program does not draw the white areas. So only the black lines are draw on your screen. You can select the transparent color by clicking on an area of the background image that has the color you want to hide. If you click on a point that lies outside the physical area of the background image transparency is disabled again. Illustration 3.6 shows an example of this.

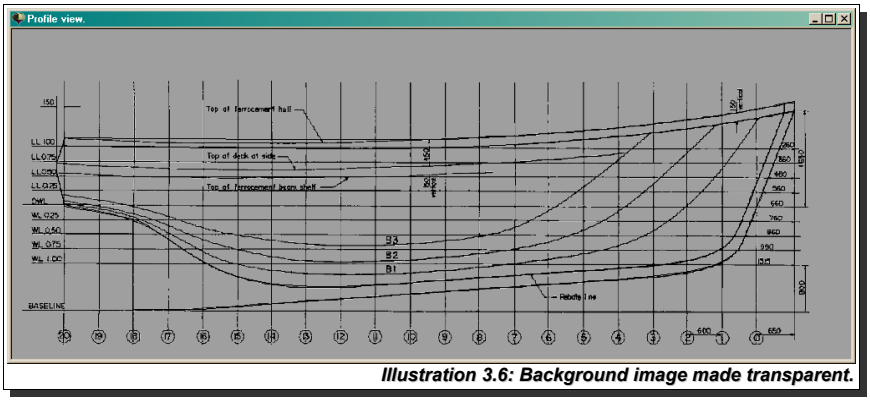


Illustration 3.6: Background image made transparent.

3.6.8 Tolerance

Sometimes images that look black and white have a lot of colors in between. This is particularly the case where some quality has been lost due to compression, as is the case with *jpg* images. When white is the designated transparent color and is filtered out, a lot of “almost white” pixels remain as can be seen on illustration 3.7. By increasing the tolerance these pixels can be filtered out by the program too.

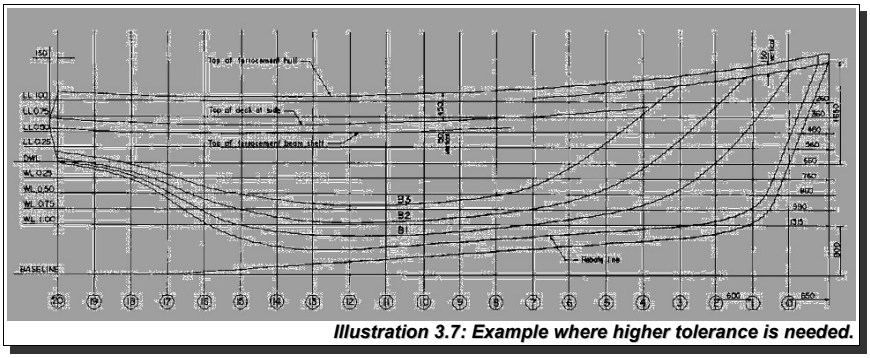


Illustration 3.7: Example where higher tolerance is needed.

3.6.9 Blending

If the background image is till too dominant it can be blended with the viewport color. This way it dissolves in the background and the geometry of you DELFTship model is still clearly visible.

4. Project settings

The project settings window will let you specify various project settings. It has a number of tab pages which can vary depending on which modules have been purchased.

4.1 General

The first tab page is used for general information about the project, such as the project name, name of the designer, some comment, the name of the person who created the file and the type of units used for this project. This can either be imperial or metric units.

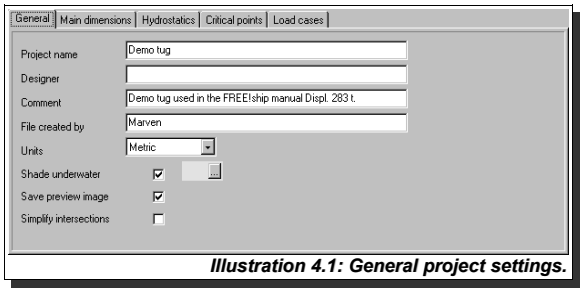


Illustration 4.1: General project settings.

When changing the unit format the entire model will be scaled to the new format. When switching from meters to feet for example all dimensions are divided by 0.3048.

- The *shade underwater* option is used to draw the submerged surfaces in a different color when viewing the shaded hull, linesplan, plate developments, and load cases.
- When *save preview* is checked a small preview is stored in the file. This is mainly used for browsing designs from the on-line design database on the DELFTship website.
- The *simplify intersections* option is more or less obsolete. When intersections such as stations are calculated the can contain a large amount of points. This option removes points that do not substantially contribute to the shape of the calculated curves, however in some rare occasions it might lead to inaccurate curves. Only when file size is of importance it might be useful to use this option.

4.2 Main dimensions

The tab sheet for main dimensions input looks as shown on illustration 4.3. The project length generally is the length between perpendiculars for large ships or the waterline length for pleasure craft.

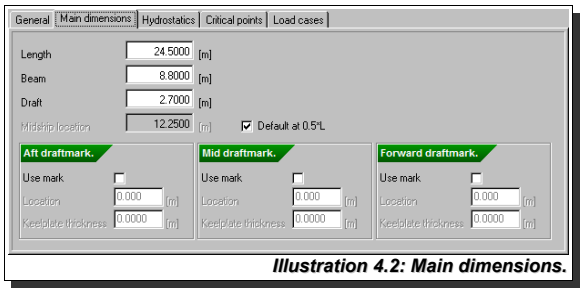


Illustration 4.2: Main dimensions.

The aft perpendicular is assumed to be located at x=0.0. The forward perpendicular is located at the positive x-coordinate that is equal to project length.

Depending on the hydrostatics settings these dimensions are used for calculating various hydrostatic coefficients such as the block coefficient. By default the midship location lies at half the project length which is generally true for large ships. For some ships different values might be specified.

The input values for the three draftmarks are optional and are only visible if the load cases module has been purchased. Here the longitudinal location of the three marks can be specified together with the local keelplate thickness. This information is used to calculate the actual draft measured from the keel under heel and trim for load cases.

4.3 Hydrostatics

Here you can modify all hydrostatics related settings, such as the density of the water and appendage coefficient. This is a factor normally used to compensate for shell thickness and appendages such as the rudder in the displacement calculation, usually in the range 1.005 - 1.010.

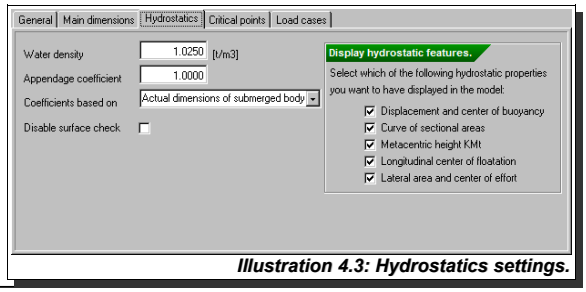


Illustration 4.3: Hydrostatics settings.

There's also a drop down box which can be used to specify how hydrostatic coefficients, such as the block coefficient and prismatic coefficient should be calculated. This can be done using either the dimensions specified in the project page (standard for large ships) or the actual dimensions of the submerged body (usually for yachts and small boats). In the latter case the submerged length and beam varies with the draft.

> The program is not able to check if the length and beam are correct. When incorrect values have been specified the calculated coefficient mentioned above will also be incorrect!

Each time hydrostatic properties need to be calculated, the program checks if the direction of the normals of faces is consistent. It also automatically corrects the direction if needed. In some rare cases it is possible that the normals point in the wrong direction after this check. If this is the case erroneous hydrostatic values are the result, such as a negative volume and displacement. If this happens it is best to first disable the automatic surface check and then manually correct the normals. When in doubt, always check the normal direction manually by selecting control faces (paragraph 5.6.2). Hydrostatics will not be calculated if leak points become submerged.

4.4 Critical points

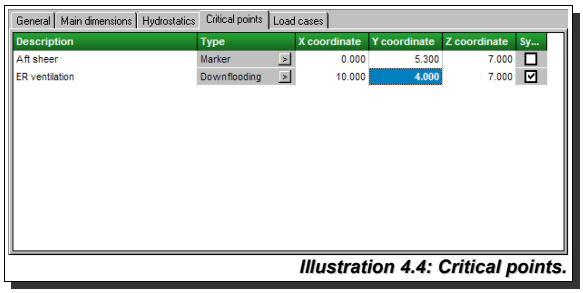


Illustration 4.4: Critical points.

The critical points page is optional. Critical points are points that deserve special consideration for stability calculations. DELFTship features the following different types of critical points:

- **Marker.** These are just points of which the user wants to know when they become submerged.
- **Downflooding.** The most important type of all. When a downflooding point is submerged it means that the ship will flood and sink. Downflooding points are used to incorporate openings in the hydrostatics calculations. These could be windows, doors, hatches, ventilation openings etc.
- **Margin line**. For future use in damage stability calculations.

Critical points are only used in the cross curves module and the load cases module. Each point needs a description that identifies it and a location in 3D space. In addition you can use the symmetry property if a critical point has a counterpart on the other side of the ship.

4.5 Load cases

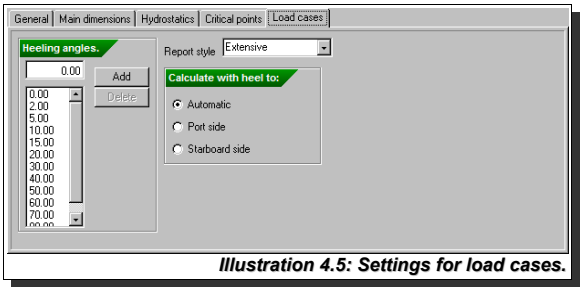


Illustration 4.5: Settings for load cases.

The load cases page is optional. For load cases a number of different settings can be altered. The most important of these are the heeling angles that need to be evaluated. For very large ships it is often not necessary to go beyond 60°, while for sailing yachts 180° is not uncommon. Only enter positive values for the heeling angles and always start with zero. The more heeling angles are calculated the more accurate the stability curve will be but how longer the calculation will take.

The program can automatically determine which side the ship heels to, but you can also force it to calculate stability with a heel to either port or starboard.

Furthermore you can choose between a short version of the load case report or the default extensive version. See paragraph 10.2.5 for more information about the load case report.

5. Edit options

5.1 Undo

Undo previous editing actions. DELFTship stores all actions into memory. When a new file is read into memory, the undo data associated with the previous model is cleared.

5.2 Redo

Redo a action that has been undone with the undo command.

5.3 Delete

Use this to delete items that have been selected. The program first deletes all selected faces, then the edges and finally the selected points. Any points or edges that appear to be unused after this process are deleted also.

> When a point is deleted all attached faces and edges are deleted too. If an edge is deleted, any attached faces will also be deleted. See paragraph 5.4.3 on how to remove a point without deleting the connected faces and edges. In paragraph 5.5.3 it is shown how to remove an edge without deleting the attached faces.

Not only items from the surface geometry can be deleted this way but also markers, control curves, flowlines and tanks.

5.4 Point

5.4.1 Add

Adds a new point in 3D space. The new point is by default located at the origin (0.0, 0.0, 0.0).
Adding new points is only enabled if the control net is visible.

5.4.2 Align

If more than two points are selected it is possible to align them so that they form a straight line. This is done by projecting all the selected points on the line that goes through the first and last selected point. They are projected to that line rather than uniformly distributed to keep the displacement of the points minimal.

5.4.3 Collapse

This removes selected points without deleting the surrounding geometry. A point can only be collapsed if it is attached to exactly two edges. The point is then removed, and the two edges are replaced by a single edge. If a point is attached to more than 2 edges, the other edges need to be removed first by collapsing these edges as explained in paragraph 5.5.3. The process of collapsing a point is shown on illustration 5.1. Note that the point that is to be collapsed is irregular since it has two faces connected to it and two edges. By collapsing the point the number of points of the two attached faces is reduced to 4. By collapsing the point the control net is made more regular and it will be easier to produce a fair hull surface.

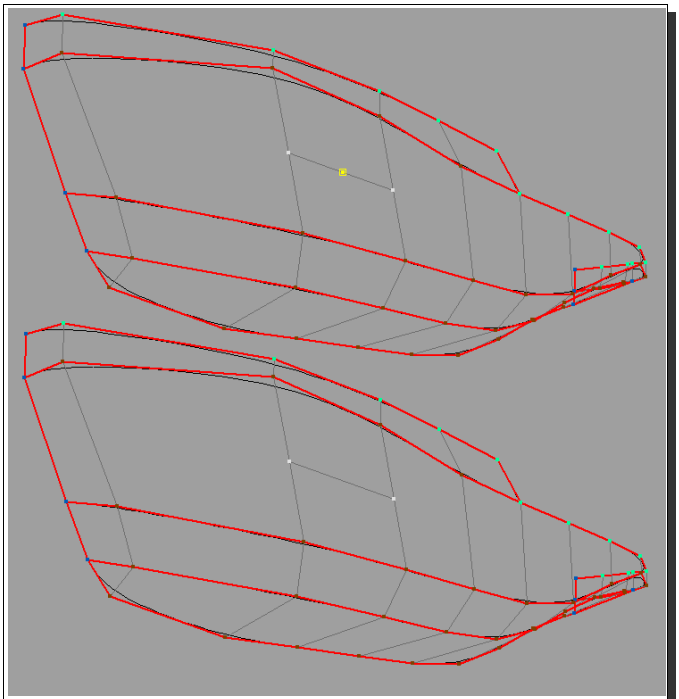


Illustration 5.1: Collapsing a point.

5.4.4 Fair points

You can use the automatic fairing routine in DELFTship to fair the entire surface for you or only selected control points. The automatic fairing routine only fairs internal points, points that are not located on crease edges. Crease edges form feature lines on the hull that are generally very important for the appearance. Therefore it is best to fair those points manually by using control curves (paragraph 5.7.2). As the automatic fairing routine is called by the user the required points are shifted to a new location in such a way that the overall smoothness of the surface improves. By repeatedly using the command a very smooth surface can be obtained but the deviation of the original surface might be significant.

5.4.5 Plane intersection

This operation intersects all visible edges with a plane. If an intersection point exists, it will be inserted on the edge. After this, faces that have multiple newly inserted points will be split by inserting a new edge. This is a convenient way to insert for example a while range of points at a certain ordinate location. There is also an option to add a control curve (paragraph 5.7.2) to the newly created edges.
The type of plane (vertical, horizontal or transverse) can be specified as well as the location by entering the desired distance into the dialog that appears.

5.4.6 Intersect layers

You can use this option to find the intersecting curve of two layers. It is only enabled if more than one layer exists. If two layers are selected then all the edges of the first layer are checked for an intersection with all the faces of the second layer. If such an intersection exists than the point is inserted in the edge. After the intersection test all inserted points are connected with new edges which form the intersecting curve of the two layers. Remember that only the first layer is affected by this operation, the second layer is left undisturbed. Another important issue is that points are only inserted in edges, **not** in faces. This option can be used for example to find the intersection of the hull with a keel or rudder.

5.4.7 Lock points

All selected unlocked points will be locked. Locked points appear dark gray on your screen and cannot be modified. None of the available editing operations has any effect on locked points. This option is only enabled if at least one point is selected that is not already locked.

5.4.8 Unlock points

This unlocks selected points that are locked, so that they can be modified again. Only enabled if at least 1 of the currently selected points has previously been locked.

5.4.9 Unlock all points

All locked points in the model will be unlocked, whether they are selected or not.

5.5 Edge

5.5.1 Extrude

The most used and desirable way to create new surfaces is by extruding edges. Since an edge may only have a maximum of two faces attached, only boundary edges are allowed to be extruded. The selected edges are copied towards the specified extrusion direction and new faces are created between each old and new edge. The new faces are assigned to the active layer (see paragraph 5.8.1)

Illustration 5.2 shows how a deck is easily added by extruding the sheerline. The three stages of the process are:

- 1.Select the boundary edges that you want to extrude. Then choose the *edge-extrude* option from the edit menu. A window shows up in which the direction of the extrusion is specified. In this case the extrusion direction is 0.0 in longitudinal direction, -2.25 in transverse direction and 0.02 upwards.
- 2.The edges are extruded in the specified direction. New faces are created and added to the currently active layer.
- 3.Move the newly created points to the centerline, and your deck is finished.

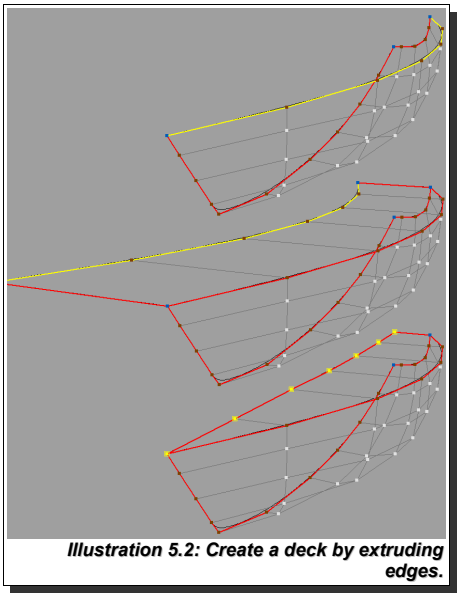


Illustration 5.2: Create a deck by extruding edges.

5.5.2 Split

Selected edges are split in two by inserting a new point in the middle. After the operation all newly created points are selected. This is a convenient way to insert new edges. In that case multiple edges can be selected and split in two. All selected points belonging to the same face may then be split by inserting a new edge. The image to the right shows two selected edges before and after the split. Note that this way a face consisting of 6 points is created, resulting in an irregular mesh (see paragraph 2.4). The two selected points should preferably be connected, thus splitting the face in two regular faces. This ensures a more regular grid and a smoother surface.

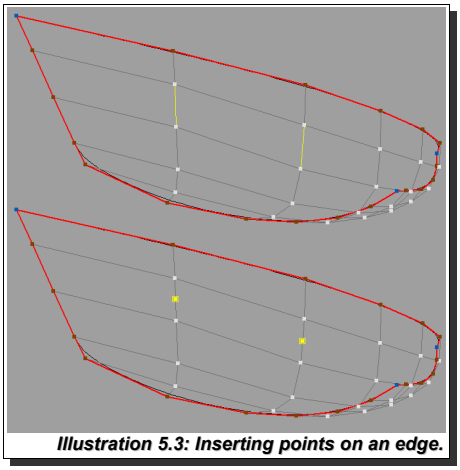


Illustration 5.3: Inserting points on an edge.

5.5.3 Collapse

Collapsing an edge removes the edge and combines the two attached faces into one new face. Edge collapsing only makes sense if the selected edge is not a boundary edge. Illustration 5.4 shows how multiple edges are collapsed in one pass. Only two points on the boundary edges remain. These can be collapsed using the *point collapse* (paragraph 5.4.3) option from the menu.

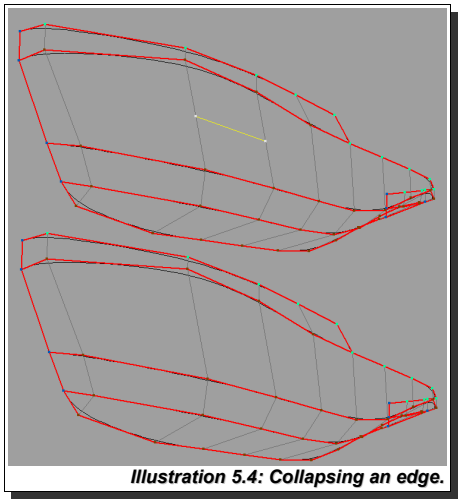


Illustration 5.4: Collapsing an edge.

5.5.4 Insert

A face can be split into two new faces by inserting an edge. To do this at least two points have to be selected. Both points must share the same face, and no edge is allowed to already exist between these two points. To ensure a fair surface it is recommended to extend inserted edges (as those seen to the right) to a crease or boundary edge if possible.

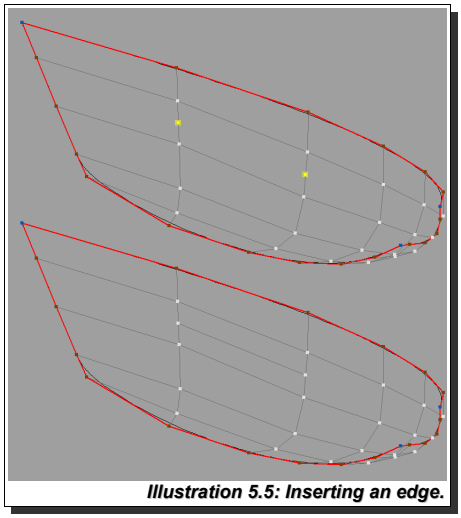


Illustration 5.5: Inserting an edge.

5.5.5 Crease

Setting selected edges as crease-edges allows the user to add knuckle lines to the hull. The crease property of boundary edges cannot be changed, they are by default treated as crease edges. Illustration 5.6 shows how a hard chine is created. To the left the model without the chine is visible. To the right the yacht with the new knuckle line is displayed. In this specific example the knuckle line runs over the full length of the hull. This is not absolutely necessary. Knuckle lines may run freely over the surface.

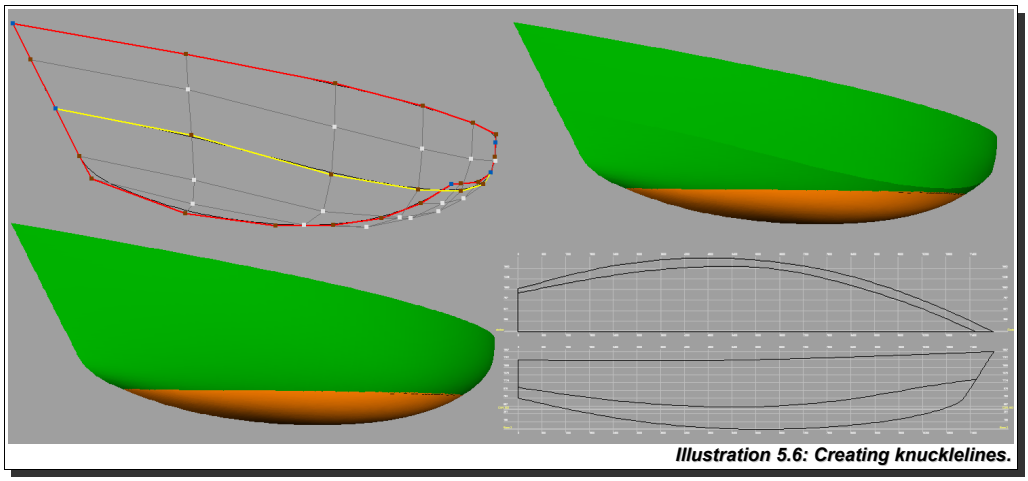


Illustration 5.6: Creating knucklelines.

5.6 Face

5.6.1 New

Creates a new face from selected points. These points have to be selected in the correct order. If looking in the direction of the new face as seen from the water, the normal of the new face points outwards if the points are sorted in counter-clockwise order. If selected in clockwise order, the normal points inside the hull. All normals should point towards the water because of the hydrostatics calculations. These are calculated directly from the surface. Normals that point into the wrong direction cause erroneous values. In some cases this shows up as negative values for the displaced volume and displacement. Luckily DELFTship automatically checks if the normal directions are correct each time hydrostatic values are calculated. For more information about this check and normal directions in general see paragraph 4.3.

5.6.2 Invert

This option can be used to manually flip the normals of selected faces to the other side if the automatic surface check fails. The normals of a face can be visualized by selecting the specific face. Make sure that both interior edges and normals are made visible in your display settings. When displaying normals, each normal is calculated as the average normal in a point of the refined subdivision mesh. This average is calculated from all faces surrounding that point. Along the boundary of an edge sharing two faces with opposite normal directions, this may seem a bit strange as can be seen on the left side of illustration 5.7. The normals along these boundaries look as if they are projected on the surface. The right side of the illustration shows the normals after the face has been inverted.

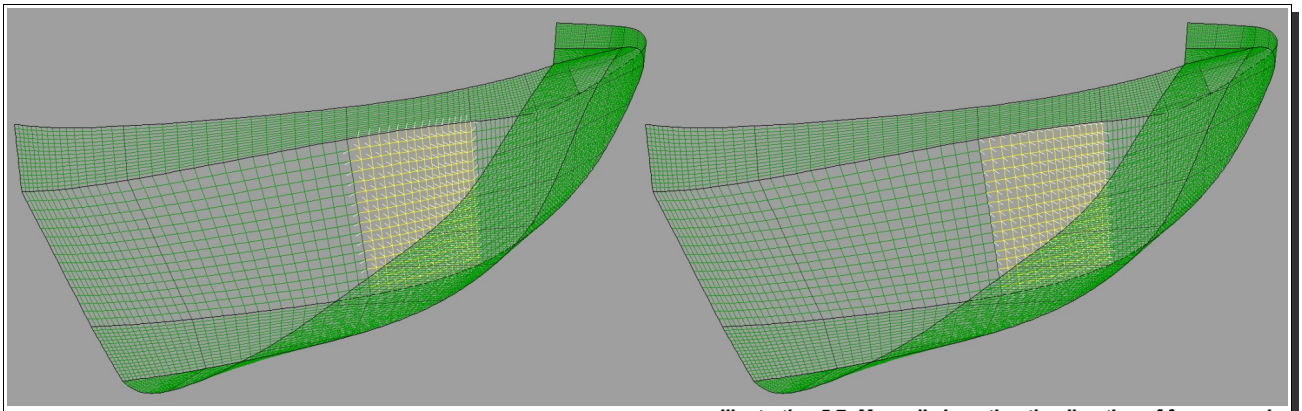


Illustration 5.7: Manually inverting the direction of face normals.

5.7 Curve

5.7.1 General information about control curves and fairing.

To have a better control over the shape of the surface, control curves can be added to the model. These control curves are assigned to edges, and after each subdivision step the new edge-points are not only inserted into the surface but also into the curve. This ensures that the control curves are always exactly embedded in the surface, regardless of the precision setting of DELFTship. If the curvature display is switched on, then the curvature plot of the selected control curves is shown also. This curvature plot is updated in real-time if one of the points is moved. If the curvature plot is interpreted and used correctly it is possible to produce a perfectly fair surface. Bumps or dents in the surface that are too small to be seen on screen with the naked eye are easily identified. Control curves are especially useful for fairing knuckle lines on the hull, such as the deckline, profile, and chines but they can also be used for fairing the surface.

So what is curvature anyway? The curvature of a curve can be defined as follows:

> *the rate of change (at a point) of the angle between a curve and a tangent to the curve*

In other words, the curvature is a measure for how strongly a curves changes in a point. It shipbuilding it is important that fair lines are produced where curvature changes gradually along a curve.

Illustration 5.8 shows a control curve in the aft part of a container ship. To the left the control curve is shown in blue, while to the right the control curve is show in a selected state (yellow) together with it's curvature plot (fuchsia). The straight parts of the curve have zero curvature. If you travel along the curve from the bottom to the direction of the deck, first the curve starts bending to the left. In this area the curvature is positive. At a height of about 2.5 meters the curve starts bending to the right, here curvature becomes negative. A little bit further along the curve it bends to the left again, so the curvature becomes positive.

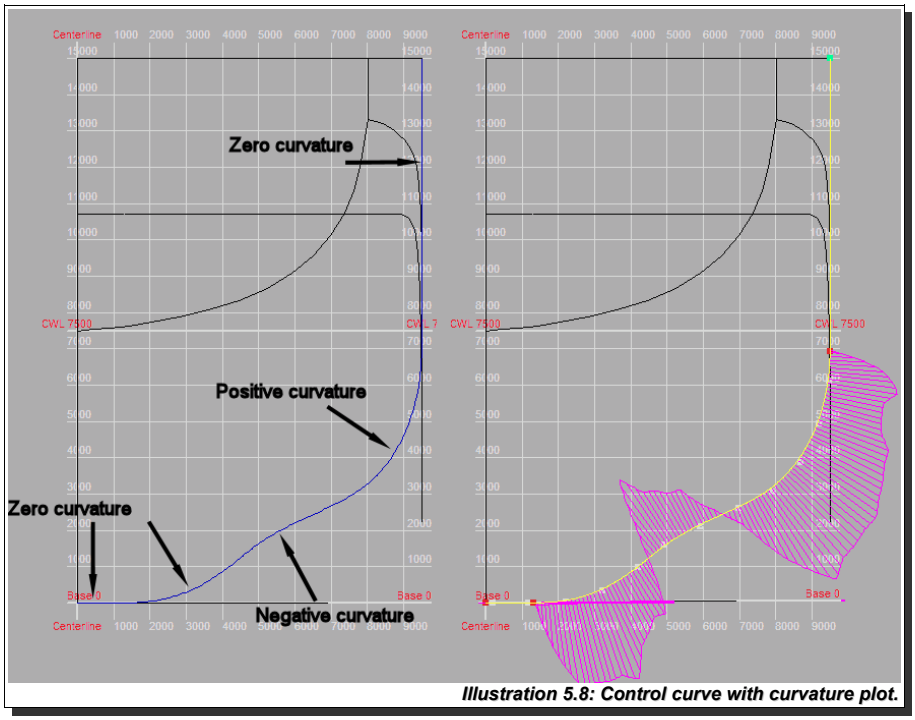


Illustration 5.8: Control curve with curvature plot.

So how is this information translated into the curvature plot? At a number of points on the curve the curvature is calculated and drawn as a line, perpendicular to the curve. The larger this line, the larger the curvature. If the curvature is positive the line is drawn on the opposite site of the curve. While the absolute value of the curvature in a point is generally not that interesting, the way it changes along the curve is. This is a measure of the fairness of the curve. You don't want abrupt changes in the curvature, it should vary as smoothly as possible. And very often, especially with small boats and yachts, a change of the sign of the curvature as seen in the image above is highly undesirable. Illustration 5.9 shows an example of a control curve from a sailing yacht. The upper part of the image shows a poorly faired curve. We see a change of the curvature sign in an area where it obviously should not occur, followed shortly after that by a sudden peak.

The lower half of the image shows the same control curve after being faired, the curvature changes gradually now and the curve is very smooth.

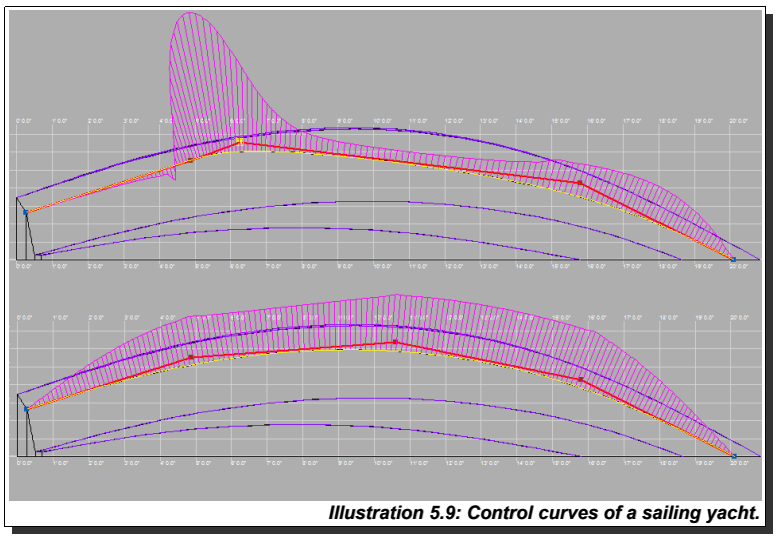


Illustration 5.9: Control curves of a sailing yacht.

One thing to bear in mind is that the curvature at the first and the last point of the curve is always zero. The curve has unclamped end conditions that correspond with a natural wooden spline batten that has no moment forced upon its ends.

Control curves are easier to fair when the points are spaced more or less evenly along the curve and are regular whenever possible. The less points a curve has, the easier it is to produce a good running smooth curve.

5.7.2 New

First select a number of connected edges. (This is easier when you hold the control key on your keyboard pressed down when selecting an edge with the mouse) Subsequently it is possible to create and assign a control curve to these edges. Only one curve can be assigned to each edge. If the new curve is not shown on the screen, make sure that control curves are made visible in your display settings.

5.7.3 Fair

The automatic fairing routine for control curves can be used to quickly let the program fair the points for you. All the points defining the curve are distributed and moved in 3D to produce a better faired curve. The deckline from illustration 5.10 was faired by using the command several times. Note that the curve has changed at the bow area also. To avoid this you can lock the points which you don't want to be affected by the fairing routine.

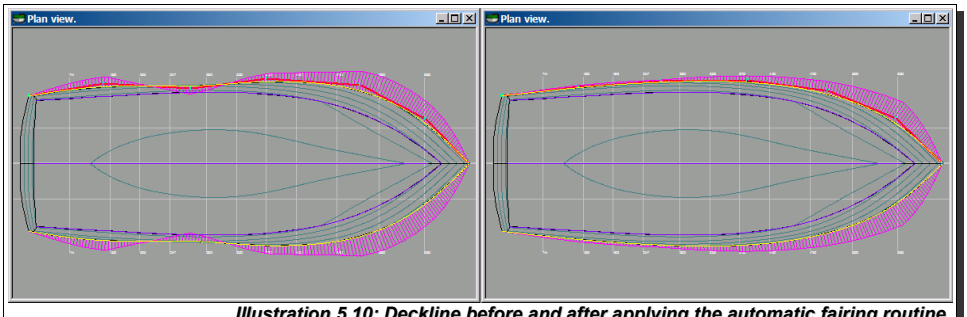


Illustration 5.10: Deckline before and after applying the automatic fairing routine.

5.8 Layer

5.8.1 General layer information.

The hull created with DELFTship consists of only 1 mathematical surface, even if multiple separated surfaces appear on the screen. When modeling it is often desirable to divide the model into different parts with different properties, such as for example the color. Therefore layers have been implemented into the program. A layer is nothing else than a collection of faces that share the same properties.

There must always be at least one layer in your model, and always one layer is said to be the *active layer*. Every new face that is added to the model will be assigned to that active layer. You can see which layer is active by looking at the layer toolbar on the top of the screen (illustration 5.11). This contains a list of all layers, and only when no faces are selected it shows the active layer. You can modify which layer is active when no faces are selected by simply selecting another layer from the drop down list in your toolbar.

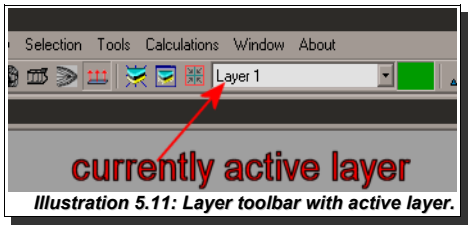


Illustration 5.11: Layer toolbar with active layer.

If there are faces selected there are two possibilities:

- All selected faces belong to the same layer. In that case that layer is shown, even if it is not the active layer.
- The selected faces belong to different layers. No layer is shown in the toolbar at all.

By selecting a layer from the list with layers while faces are selected, all the selected faces will be removed from their current layer and assigned to this selected layer.

5.8.2 Active layer color

Modify the color of the active layer. This color is also visible in the toolbar, right next to the drop-down box containing the layer names..

5.8.3 Auto group

This extracts groups of faces which are totally surrounded by crease edges. Then each group of faces is assigned to a new layer. If no faces are selected, every visible layer will be processed, otherwise only the selected faces. DELFTship tries to save as much of the present layer information as possible. If a set of faces is extracted, and they already belong to the same layer then this layer is left undisturbed. Auto grouping is only enabled when the display of interior edges is switched on.

5.8.4 New

Add a new and empty layer to the model and make it the active layer.

5.8.5 Delete empty

Only enabled if the model contains at least two layers and at least one empty layer. All empty layers are removed from the model. This also includes the active layer if it is empty. At least one layer remains as the active layer.

5.8.6 Dialog

This brings up the window showing all layers and their properties. The left half of the window shows a list containing all the available layers. By clicking on a layer it will be selected and all its properties are displayed to the right. Double clicking on a layer in the list on the left side makes it the active layer. From within this window it is possible to turn layers on or off or to modify the following layer properties:

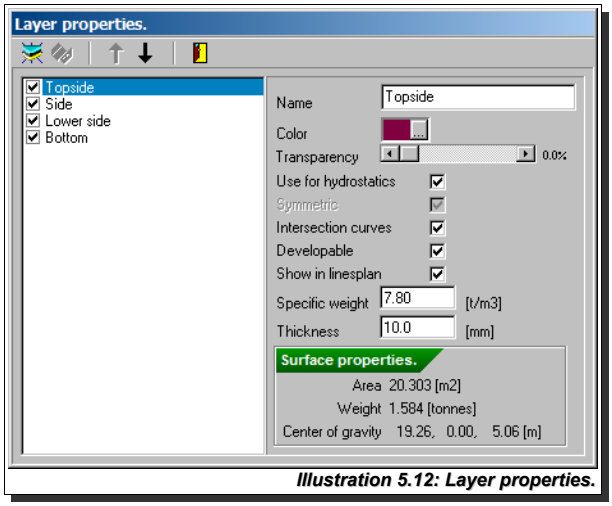


Illustration 5.12: Layer properties.

- **Visibility.** The check boxes on the left side nect to the name indicate whether the corresponding layer is visible on screen or not. Click on the check box to turn the layer on or off. Points or edges from the control net belonging to invisible layers are also hidden, which makes modeling of complex models easier.
- **Name.** The layer name is displayed in the list at the left, but it can only be modified at the right side of the window. DELFTship does not require the layer name to be a unique name, since all layers are identified by an internal unique identification number. Some CAD programs however, such as Autocad, do not allow spaces in the name of a layer or duplicate names. Exporting to such a program can cause problems if layers with identical names are used. It is therefore advisable to always use unique names for each layer.
- **Color.** The layer color is used for shading the model. It is also used in the linesplan and for plate developments. The color of a layer can be modified by clicking the colored square to the right. A window appears in which a new color can be chosen.
- **Transparency.** Sometimes it is nice to shade certain surfaces (partially) transparent, such as windows for example. The amount of transparency can be modified by moving the slidebar. The amount of transparency can range from 0% (totally solid) to 100% (invisible). Note though that transparent shading might consume a lot of memory and significantly slow down the shading process. Since normal Z-buffer shading or plain alpha blending produces strange artefacts, the only way to do this properly is by keeping track of all surfaces covering a particular pixel on the screen and then drawing all these surfaces from the back to the front. This costs extra memory and CPU time, but apart from being a bit slower it should not pose any real problems.
- **Symmetric.** Only layers that do **not** contribute the hydrostatics can be a non-symmetrical. So generally it can not be used to create asymmetrical hulls. It can be used however to add asymmetrical deckhouses or other objects on the hull, such as sails, people etc.
- **Use for hydrostatics.** DELFTship uses the faces of the subdivision mesh for hydrostatic calculations (see paragraph 11.3) It calculates the volume enclosed by these faces. Sometime however there are surfaces present in the model that should not be included in the hydrostatic calculations. This is particularly the case if the faces of a layer do **not** form an enclosed volume, but only a surface, such as a sail for example. If a sail were to be included in the calculations, DELFTship would calculate the volume aft of the sail (if it is submerged) as a volume. Since this volume extends to infinity (there is no backside surface present) it would introduce an error. So specific layers can be excluded from the calculations. See also paragraph 7.1 for more information concerning leak points.
- **Intersection curves.** This property tells the program if a layer should or should not be included when intersection curves are calculated. For complex models it is often convenient to display stations, buttocks, waterlines and diagonals of the hull only, and not for the deck, superstructure etc. This setting has **no** influence on the hydrostatics.
- **Developable.** Developable hulls are very interesting to shipbuilders since they can be build from flat plates which are only bend in one direction. Most hulls are not developable since the surface is curved in two directions (called compound curvature). Developable layers can be shaded differently. Developable areas of these layers are shaded green while undevelopable areas are shaded in red. This is a convenient way to check if a hull is indeed developable. Illustration 5.13 shows an example of a developable tug. It can immediately be seen by the green color that almost the entire hull is

developable. Just a few very small spots in the topside and a larger area in front at the bottom are colored red. Those very small spots are mostly numeric errors (DELFTship uses a very small tolerance). The larger bottom area however is not developable from a mathematical point of view.

Developable hulls are often made of plywood, which is far easier to bend than metal as a result of different material properties. In reality layers that are “almost” developable can perfectly be build using plywood, whereas the same hull build of metal requires “torturing” the metal to get it into shape.

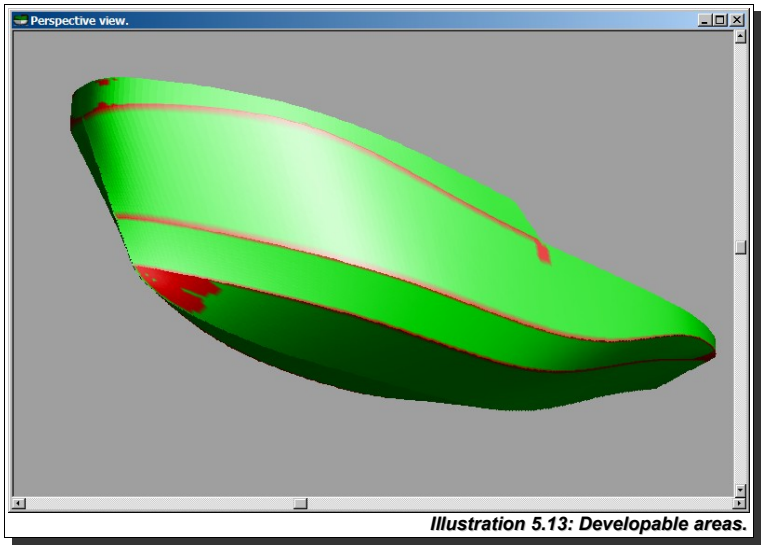


Illustration 5.13: Developable areas.

Developable layers can be unfolded (or developed) by the program onto a flat plane for building purposes. This will be explained in paragraph 11.6.

- **Show in linesplan.** Sometimes a layer contains items you don't want to be seen in the linesplan. An example of this could be a mast and sails. These are relatively high compared to the rest of the boat. Showing these in the linesplan view would cause the hull to appear very small. Therefore some layers may be hidden. Be aware though that the scale of items in the linesplan is also determined by the intersection curves. If a layer would contain a sail, and the intersection curves property is checked, intersection curves of this sail would still be calculated and seen in the linesplan. Therefore it is best if you want to hide layers from this view to also disable calculating intersection curves from those layers.
- **Material properties.** There are two input fields at the bottom that can be used for a weight estimation of a layer. In the “*specific weight*” field the density of the used material can be entered, for example 7.8 tons/m3 in the case of steel. In the field below that the average thickness can be specified. These two properties combined with the total area of the surface assigned to this layer result in a weight estimate and corresponding center of gravity. This is shown when the design hydrostatics are calculated (paragraph 11.3).

Below the material properties the surface area, weight and center of gravity of the selected layer are displayed. The black up and down arrows in the toolbar can be used to move a selected layer up or down in the list. Developable layers will appear in the same order in the window with developed panels.

6. Display

6.1 Controlnet

The controlnet is the combination of all points and edges that form the initial subdivision mesh. These are the entities that can be manipulated by the user to shape the surface. If all the faces attached to a certain point or edge belong to layers which are turned off, it will not be drawn on the screen. That way only the points or edges of interest will be shown.

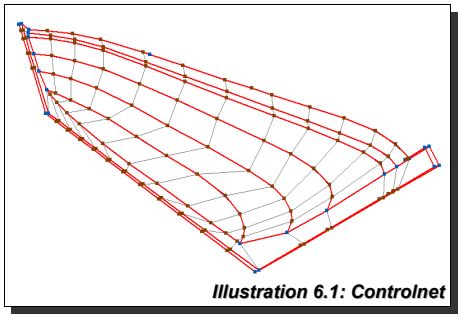


Illustration 6.1: Controlnet

6.2 Control curves

Control curves are curves that are assigned to edges of the controlnet and are used to fair the surface. The visibility of these control curves is not depending on the visibility of the controlnet. In fact, selecting and manipulating control curves is often easier if the control net is not visible. Points and edges assigned to a control curve automatically become visible whenever a control curve is selected.

6.3 Interior edges

The interior edges are in fact the edges of the subdivided surface. The higher the precision is set, the more edges are shown. The interior edges are drawn in the color of the layer they are assigned to.

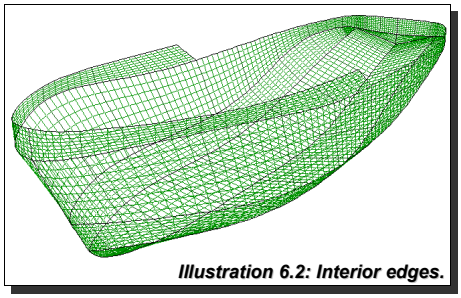


Illustration 6.2: Interior edges.

6.4 Show both sides

Since almost any ship is symmetrical with respect to the center plane, only the portside of the hull is modeled. If less information is shown it is easier to select a point, edge or face. Both sides can be shown however so that the designer has a good impression of what the entire hull looks like. Not only the surface is drawn symmetrical, also the intersection curves, flowlines, control curves etc. Showing both sides of the hull is possible in both wireframe view and shaded view.

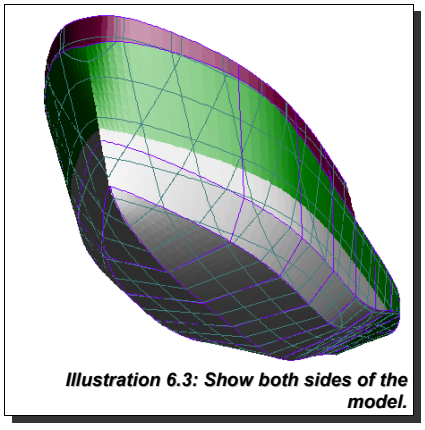


Illustration 6.3: Show both sides of the model.

6.5 Grid

If intersection curves are added it is also possible to have a grid displayed. This grid marks the location of these intersection curves. It is visible in wireframe and shaded mode and next to each line its distance is printed. In addition the baseline, centerline and design waterline are also indicated. The grid is visible in all views except for the perspective view. This grid is shown, regardless of the display settings of the intersection curves. The same grid is also visible in the linesplan. See illustration 6.4 for an example.

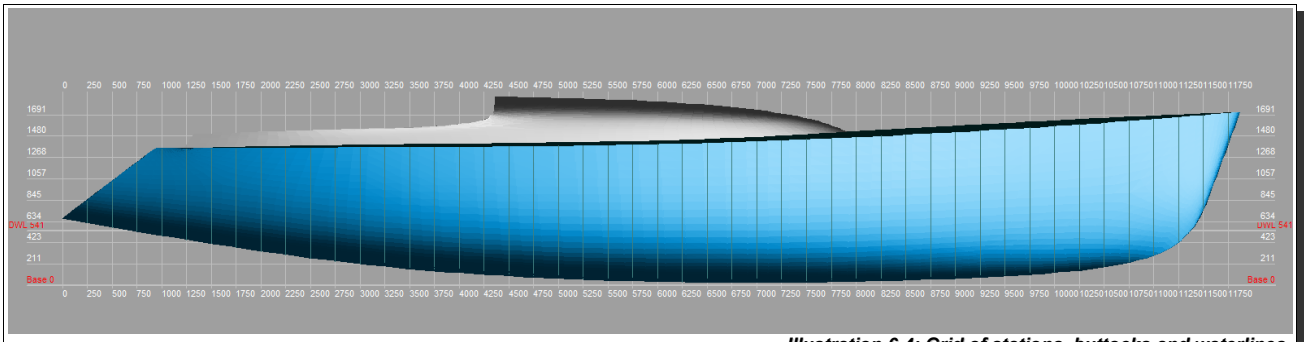


Illustration 6.4: Grid of stations, buttocks and waterlines.

6.6 Stations

Use this option to draw or hide stations to or from the screen. This option is only enabled if the model contains stations.

6.7 Buttocks

Use this option to draw or hide buttocks to or from the screen. This option is only enabled if the model contains buttocks.

6.8 Waterlines

Use this option to draw or hide waterlines to or from the screen. This option is only enabled if the model contains waterlines.

6.9 Diagonals

Use this option to draw or hide diagonals to or from the screen. This option is only enabled if the model contains diagonals.

6.10 Hydrostatic features

DELFTship also provides the option to plot some key hydrostatic values in the model. These are:

- Displacement and center of buoyancy
- Center of flotation
- Lateral area and center of effort
- Transverse metacentric height
- Curve of sectional areas. Contrary to the other values this curve is only plotted in the profile view of the hull.

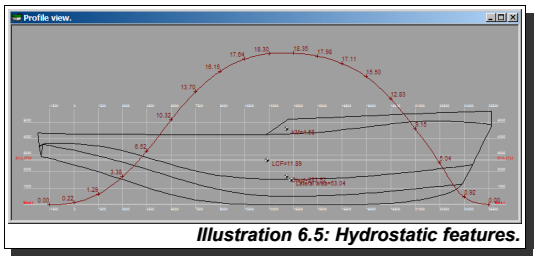


Illustration 6.5: Hydrostatic features.

Of course these values can only be shown if the model is consistent enough to calculate the hydrostatics at the design draft (so no leak points below the waterline). The values are updated in real-time when the model is being modified. You can specify which data you want the program to show in the project settings window (see paragraph 4.3)

6.11 Critical points

Optional. Critical points can also be displayed. See paragraph 4.4 for more information regarding critical points.

6.12 Flowlines

Option to show flowlines. The flowlines that are displayed by DELFTship are calculated through analysis of the surface geometry only and have nothing to do with CFD. This is a huge simplification as speed, pressure and waves are excluded from the calculation. Despite this simplification the flowlines show a remarkable resemblance with those calculated with CFD programs, but they only are added to give the designer an impression of how the water will approximately flow. Real CFD calculations are of course much more accurate and reliable.

Flowlines are added by keeping the alt-button pressed and clicking with the mouse on a point below the waterline (profile, plan or body plan view only). This point is used as the origin of the flowline. From there the flow is traced as far as possible to the stern until it penetrates the design waterline.

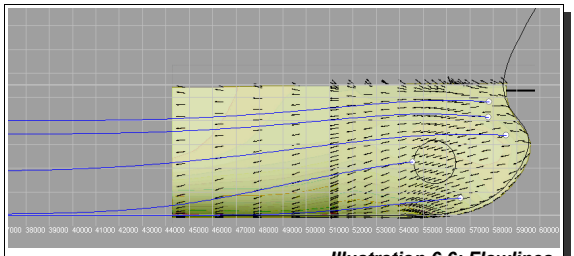


Illustration 6.6: Flowlines.

Flowlines are only traced along surfaces that belong to a layer that is also used for hydrostatic calculations (generally the shell of the hull). The image above shows some flowlines at the bow of a hull with a bulb. The background image shows the results from a CFD calculation. The small black lines represent the direction of the flow as calculated with CFD, the blue curves are the flowlines calculated by DELFTship. Flowlines can be selected and deleted like any other geometry.

Areas on the surface where flowlines are converging to each other are high pressure areas whilst areas where the flowlines diverge are low-pressure areas.

6.13 Normals

If this option is switched on, normals of **selected** faces are displayed. The normals are drawn as thin white lines, pointing either inward or outward the hull (illustration 5.7). This option is only enabled if interior edges are displayed (paragraph 6.3). One normal is drawn at each interior point of the subdivision surface. The higher the precision is set, the more normals are drawn.

6.14 Curvature

This option enables or disables the drawing of the curvature plot of control curves and certain intersection curves. Only of intersection curves which appear checked in the intersection dialog (paragraph 11.1) will the curvature be plotted.

6.15 Markers

Markers are curves that are added to the model as a reference. For example the body plan of an existing design could be imported as markers. Stations could then be added to the DELFTship model at the same location as the markers. Finally the points can be dragged until the stations and the markers are exactly on top of each other. In that case the DELFTship hull matches the hull from the existing design.

6.16 Tanks

Enables/disables the drawing of tanks. If the model contains tanks and a number of modifications to the hull have to be performed it is better to turn of the displaying of tanks. Otherwise all tanks have to be rebuild after

each hull modification which can be time consuming.

6.17 Sounding pipes

Display sounding pipes of tanks (only enabled if the model contains tanks).

6.18 Transparent tanks

Switch between solid shading of tanks or transparent shading.

6.19 Tank names

Display the names of tanks in the model.

6.20 Curvature scale

The scale of the curvature plot of control curves and intersection curves can be decreased by pressing the F9 key, so that curves with high curvature can be evaluated. Pressing F10 increases the curvature scale.

7. Tools

7.1 Check model

DELFTship can check the model for any inconsistencies, and corrects most of them automatically. This check is also performed each time hydrostatics are calculated, unless automatic checking is disabled in the project settings (paragraph 4.3) . First of all the surface is checked for any disjoint segments. Then each segment is checked for a consistent direction of the face normals. If not, it adapts those faces. Nest the lowest point of each segment is identified. For ships this usually is the bottom. If this is indeed a point on the bottom then the average normal of this point should point down. Under this assumption all faces are adapted such that the direction of their normal corresponds to the direction of the normal of this particular point. In some rare cases this might cause the normals to point in the wrong direction. In that case it is recommended to manually flip the normals to the correct side and to disable automatic checking of the surface. This test also identifies edges with more than two faces attached. Secondly a list of leak points is provided where the hull is considered leak. A point is considered “leak” if:

- It is **not** situated on the center plane, meaning that the y-coordinate of the point >0.0001.
- The point is situated on a boundary edge (An edge with only 1 face attached to it).

Note that for hydrostatic calculations an edge counts also as a boundary edge if two faces are attached to it of which one is excluded from hydrostatic calculations. This could for example be the case for a ship with a closed deck, from which the deck is put in a separate layer that is not included in the hydrostatics calculations. In that case DELFTship keeps calculating until the deckline is submerged. Also windows or any other none watertight surfaces could be treated this way.

It is important to realize that leak points are not actually always leak in the sense that they are always making water. A leak point in DELFTship is a point that is **potentially** leak and only becomes actually leak when submerged. So the presence of leak points does not always have to be a problem, just as long as they are not submerged.

If more then 10 leak points are found, only the first 10 are displayed. The points are shown sorted in increasing height above the base plane.

Finally, if the test is called from the menu, an overview of corrected items and possible remaining errors is shown.

7.2 Remove negative

Sometimes, when a hull is imported, the geometry of both sides of the ship is present. DELFTship only needs the port side. This option removes all faces from the model that are completely on the starboard side.

7.3 Remove unused points

Remove all points from the model that have no edge or faces connected to it.

7.4 Keel and rudder wizard

The keel and rudder wizard enables you to quickly define a keel or rudder with a predefined planform. You can select the desired wing section from a list of standard NACA sections. The keel or rudder is show in 3D along with it basic properties such as aspect ratio, volume, center of buoyancy etc. Once the keel or rudder is complete it can be exported in two ways. Using the “send” button it is inserted at the current DELFTship model at the origin. Using the “save as part” button it can be saved to disc as a DELFTship part which can be imported in other designs. The lift/drag tab shows an estimation for the lift and drag curves.

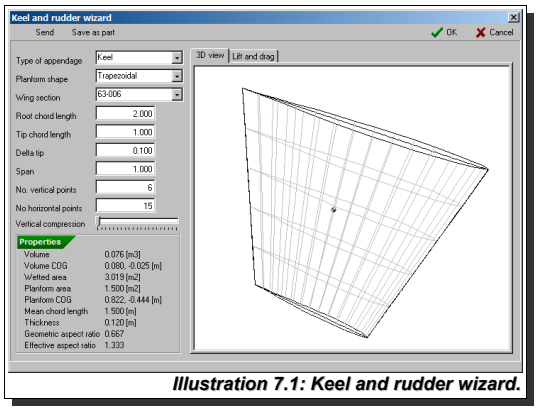


Illustration 7.1: Keel and rudder wizard.

7.5 Markers

7.5.1 Import

Markers are curves that can be added to the model as a reference. For example the offsets of another design can be imported as markers. Then intersection curves can be specified at the same locations in DELFTship. If the intersection curves coincide with the markers both hulls are exactly the same. At the moment the only way to add markers is by importing them from a text file.

7.5.2 Delete

This deletes all markers from the model. It speaks for itself that this option is disabled if there are no markers added to the model.

7.6 Add cylinder

Lets you add a cylinder to the model. You can specify the start point, endpoint, radius and number of points in the window that appears. The points are calculated in such a way that the resulting surface has the required properties, even though the points are located outside the cylinder. The minimum number of points that can be used to form the cylindrical shape is 4, however 6 or more is recommended. You can use the cylinder for example to add a bow thruster to your model.

8. Transform

The first following 4 transformation operations described in this chapter are intended to be used on a selection. There are two different ways to create such a selection.

1. Select the items manually with the mouse
2. Select nothing. As soon as one of the commands below is chosen and no selection exists, the program shows a window from which you can select the appropriate layers. Then the operation is performed on the selected layers.

8.1 Scale

Scales (part of) the model. For this operation the program assembles all selected points, but also all the points that belong to edges and faces that are selected. If nothing is selected, a window is presented to the user from which entire layers can be selected. If the checkbox at the bottom of the dialog is checked (the one saying: “include points that are shared with unselected layers”) then a point is selected automatically if *at least* one attached face belongs to a selected layer. If the checkbox is not checked, then a point is selected automatically when *all* the faces around it belong to selected layer(s). If everything is selected, then not only is the hull scaled, but all other information such as main particulars, intersection curves, tanks and critical points too.

8.2 Move

Moves (part of) the model. Works on points extracted from a selection, as described in paragraph 8.1.

8.3 Rotate

Rotates (part of) the model. Works on points extracted from a selection, as described in paragraph 8.1.

8.4 Mirror

In contrast to the previous transformation commands this one is based on selected faces, not points. First select all the faces you want to mirror. Then use the mirror command to create a mirrored copy of the selected faces. The mirror plane can be either transverse (YZ plane), horizontal (XY plane) or vertical (XZ plane). The distance of the mirror plane to the origin must be specified in the distance field. The checkbox at the bottom of the form tells the program if the mirrored points should be connected to already existing points or not.

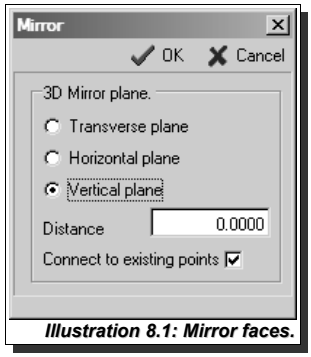


Illustration 8.1: Mirror faces.

8.5 Hullform transformation

DELFTship has the ability to automatically adjust some hullform parameters. You can use two different types of transformation:

- The hullform transformation method developed by Lackenby is used to transform the hull to match a desired displacement or longitudinal center of buoyancy while maintaining fairness of your design. This is done by shifting control points in the longitudinal direction. So the overall length of the design will be different after the transformation. The window looks as shown in illustration 8.2.
- The midship coefficient transformation adjusts the shape of the hull so that a specified midship coefficient is met. Note that after this transformation the displacement is also altered. If both the midship coefficient and the displacement need to be modified it is advised to adjust the midship first before transforming the hull to the desired displacement or center of buoyancy. The midship coefficient transformation might result in a distorted deckline.

The input fields to the left are divided in 3 columns. The left column shows the current values as calculated from the model. The middle column shows the desired values which can be modified by the user. Depending on which transformation method is selected some input fields can be disabled. The right column shows the difference between the current and desired values. The left and right column are updated after each iteration so the progress can be monitored.

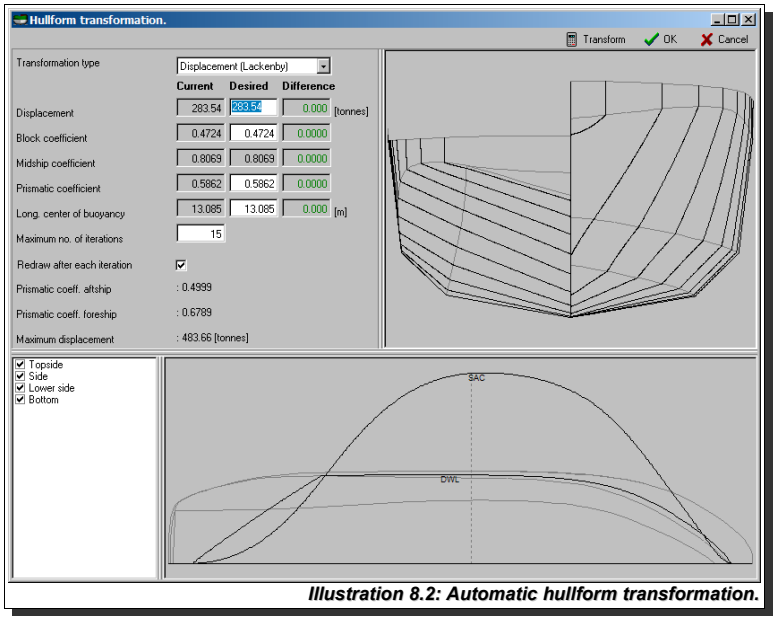


Illustration 8.2: Automatic hullform transformation.

Below these 3 columns the maximum number of iterations that may be performed can be modified. The default is 15, but sometimes more iterations are needed to obtain the desired result. This is specially true when a design has a high prismatic coefficient in the aftship, such as planing motorcraft, or when the midship location is far from the usual place at 0.5*Length.

The checkbox below that ensures that all windows of the program are updated after each iteration, so the progress can be monitored in 3D.

As can been seen on illustration 8.3 is the bodyplan of the original hull displayed in black. If the transformation was successful then the transformed bodyplan is displayed in red dashed lines on top of the original bodyplan to visualize the difference between the original and transformed hull.

At the bottom of the window the original sectional area curve and design waterline are displayed, also in black. Again the new sectional area curve and design waterline are displayed on top of these if the transformation was successful. The dark gray dashed line is the location of the midship section as defined by the user in the project settings. It is important to know that in contrast to the hydrostatics calculated elsewhere in the program here it is calculated using ordinates, and not surface panels. This can cause a slight difference between the displacement shown here and calculated elsewhere. A total of 82 ordinates is used to calculate the sectional area curve and hydrostatics, 41 for the aftship and 41 for the foreship.

Finally at the bottom-left corner all layers of the model are shown. The transformation is only applied to the layers that have a check mark next to them. As stated previously the transformation consists of shifting control points longitudinally, so the location of for example a keel, centerboard or cabin is also likely to change. By excluding layers from the transformation they remain unchanged, but it may result in a distorted or unfair model if the model was excessively changed.

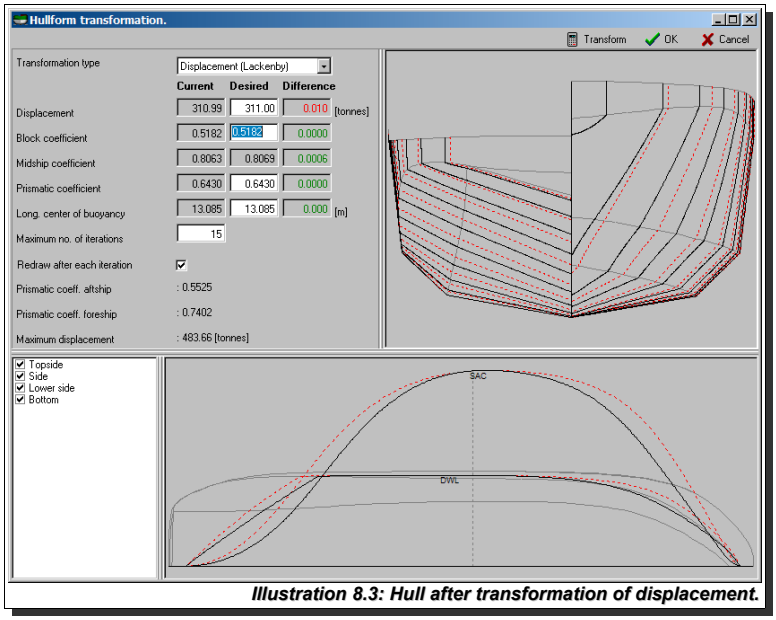


Illustration 8.3: Hull after transformation of displacement.

9. Tanks

9.1 General information about tanks

Tanks are modeled as 3D volumes and described by surfaces, just like the hull shape. The biggest advantage of this is that a higher accuracy is obtained, especially when the volume of a tank is calculated under trim and heel as is the case when load cases are calculated. In order to be able to create complex shapes, tanks are created from multiple parts called compartments. To create complex tanks you can use as many compartments as you like (see illustration 9.1) Tanks and compartments may be deleted by selecting them in the tree and pressing the delete key. It is also possible to drag a compartment from one tank to another with the mouse. Although the compartments are modeled as separate items all compartments within a tank are treated as one, meaning that the fluid level in all compartments is the same. If one of the compartments of a tank could not be build properly, both the compartment and tank it belongs to will have an exclamation mark displayed next to them in the tree (illustration 9.2). This makes it easy to see if your model contains any invalid tanks. A compartment should be fully closed at all sides after it has been build. If this is not the case the exclamation mark will appear and the model contains some purple edges. These are the edges where the compartment could not be closed. In the case of illustration 9.3 the top of the compartment was extended to the deck while there is no deck in the ship. Therefore the aft, top and front side could not be closed. The remedy for this specific case is to either drop the top of the compartment to below the sheerline or to create a deck to make the hull closed.

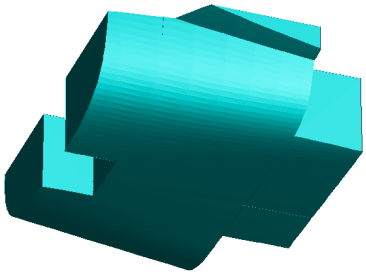


Illustration 9.1: Tank made out of multiple compartments.

Illustration 9.2: Invalid tank.

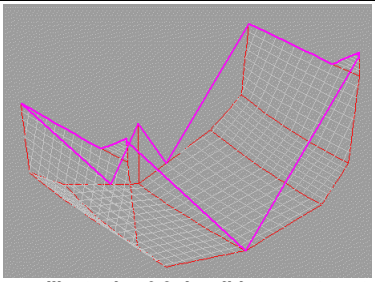


Illustration 9.3: Invalid compartment.

9.2 Edit

Illustration 9.4 shows the tank editor window. There is no menu, all edit commands are accessible through the toolbar at the top. The tree structure to the right shows all the available tanks and compartments. By selecting a tank or compartment a panel appears at the top showing the properties of that item. Only the item that is currently selected is drawn. If no tank or compartment is selected all the available tanks will be drawn. This can be done by clicking on the white area at the bottom or to the right of the tree.

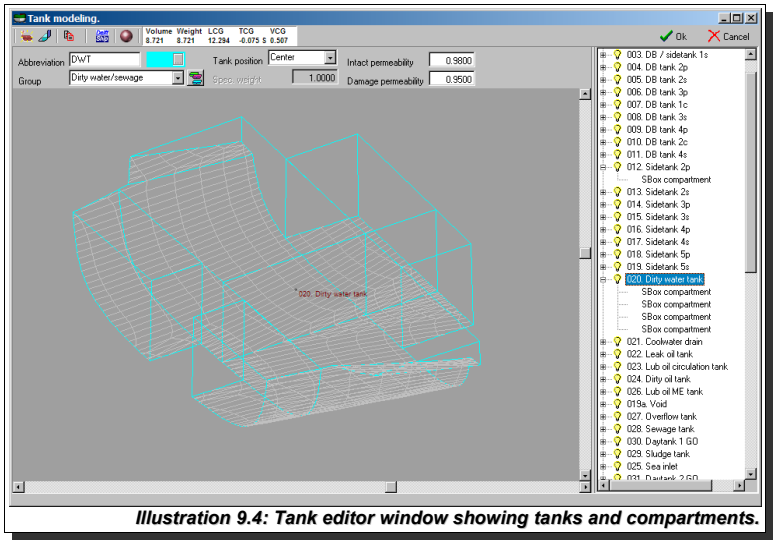


Illustration 9.4: Tank editor window showing tanks and compartments.

9.2.1 Adding a tank

Press the *new tank* button on the toolbar or the *insert* key on your keyboard.. A new tank will be added to the tree and is automatically selected. The new tank contains 1 compartment by default. You can modify the following properties of the tank:

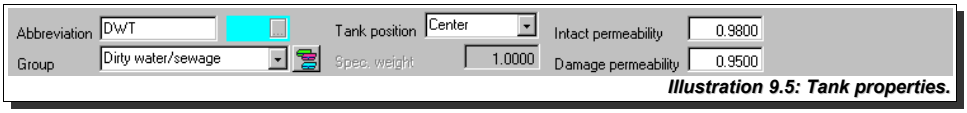


Illustration 9.5: Tank properties.

9.2.1.1 Abbreviation

A short description of the tank. The full description, that is shown also whenever the tank is drawn on screen, can be changed by clicking on the name of the tank in the tree.

9.2.1.2 Tank color

You can set the color of the tank by clicking on the colored box next to the input field for the tank abbreviation. You can choose any color you like. This option is disabled however if the tank has been assigned to a tankgroup because all the tanks in a tankgroup share the same color.

9.2.1.3 Group

You can add a tank to a tankgroup by selecting a tankgroup from the drop-down list. Tankgroups are, just as the name implies, groups of tanks with the same properties. This is especially useful if you have multiple tanks with the same contents. To manage the tankgroups you should press the small button next to the list with tankgroups:

The following window then shows up:

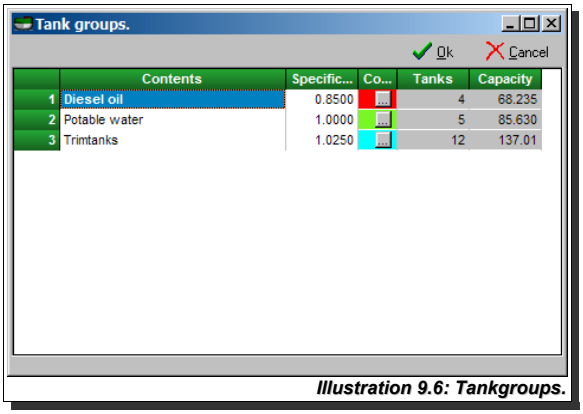


Illustration 9.6: Tankgroups.

In this window you can add, delete and modify your tankgroups. You can also see how many tanks are assigned to each group and what the total capacity (weight) of these tanks is. This makes it easier to see for example how much fuel or ballastwater you can load. See also paragraph 9.3.

9.2.1.4 Tank position

The tank position indicates on what side of ship the tank is located (port, starboard or center). By modifying this **all** compartments of this tank will switch to the indicated side. You can also modify this on a compartment-level by selecting the appropriate compartment.

9.2.1.5 Specific weight

The specific weight of the contents of the tank. This is disabled if the tank is assigned to a tankgroup because it then uses the specific weight of the tankgroup. The specific weight is given in ton/m^3.

9.2.1.6 Intact permeability

The intact permeability is the permeability of the tank which is used for calculating the volume when loaded with fluids. Due to the fact that the walls of the tank have a thickness and normally also construction parts on them the real internal volume is always smaller than the volume as calculated from the surface describing the outer side of the tank. Therefore the permeability is always a number between 0.0 and 1.0. By default the permeability is set to 0.95. For tanks with no internal construction parts this could be set to 0.98-0.99.

9.2.1.7 Damage permeability

See also paragraph 9.2.1.6. The damage permeability is slightly different though. This is the permeability which is used for calculating damage stability. This differs from the intact permeability because of the fact that most spaces in a ship have stuff stored in them. The volume occupied by this stuff can not be filled with water when the space is flooded and therefore a separate permeability is used in case of damage. The default damage permeability for an engine room for example is 0.85 due to all the installed machinery.

9.2.2 Adding a compartment

You can add a new compartment by selecting the appropriate tank and pressing the *new compartment* button from the toolbar. The new compartment is added to the tank and automatically selected.

The following compartment properties can be modified:

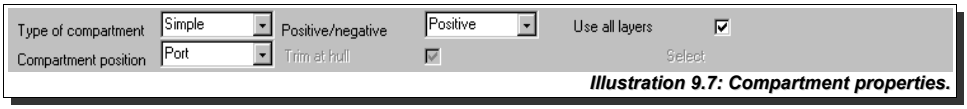


Illustration 9.7: Compartment properties.

9.2.2.1 *Type of compartment*

Basically there are two type of compartments available in DELFTship at this stage.

- **Simple.** The most used type of compartment. The shape of the compartment is defined as a simple box that is trimmed against the hull (see also paragraph 9.2.2.4) You can specify only the aft, forward, inner, outer, lower and upper boundary of the compartment as shown on illustration 9.8. In the input fields you can either enter an absolute value/number or the identifier *shell* which tells the program that the compartment extends to the shell.

  Compartments are all modeled at the port side of the ship, so only positive values are accepted in the input field for breadth values. You can switch a compartment from the portside to starboard as described in paragraph 9.2.2.2.

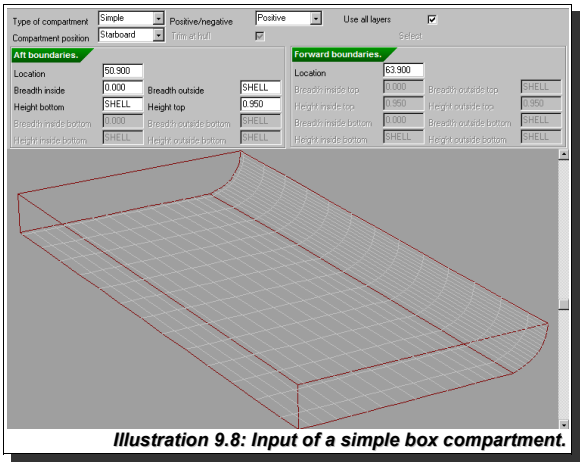


Illustration 9.8: Input of a simple box compartment.

- **Advanced.** In some cases compartments have tilted sides. If you set the compartment type to *advanced* you can enter the coordinates of each cornerpoint of the compartment's bounding box. For each side DELFTship fits a plane through the four cornerpoints. This plane is used to build the compartment.

  The sides of a compartment that do not extend to the shell are always flat, regardless of the values specified for the cornerpoints.

  A plane is uniquely described by three points in space. If the fourth point of a side is not exactly on that plane the average plane through the four points is used.

  Illustration 9.9 shows the input fields of an advanced compartment.

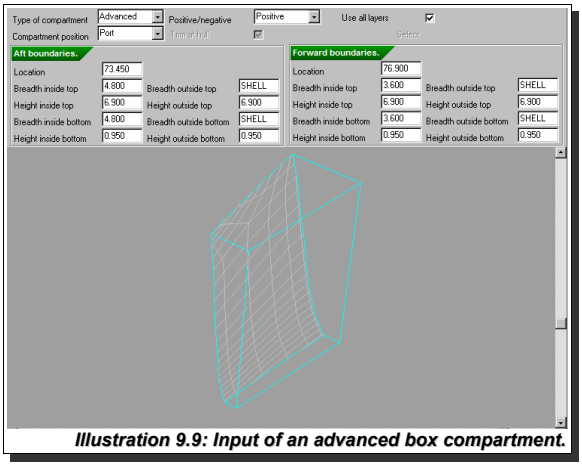


Illustration 9.9: Input of an advanced box compartment.

9.2.2.2 *Compartment position*

While modeling compartments only positive numbers are allowed for the breadth values. This is due to the fact that only 1 side of the hull is physically present in the program. By modifying the *compartment position* setting you can switch a compartment to starboard side or both sides of your ship. You can also do this on a tank level as explained in paragraph 9.2.1.4.

9.2.2.3 Positive/negative

Sometimes tanks contain recesses that are difficult to model. In fact it might be simpler to model that recess and subtract it from the total tank rather than modeling the parts of the tank surrounding the recess. When a compartment is set to negative all properties such as volume, COG, free surface moment etc. are subtracted from the total tank. Be careful not to subtract a larger volume than the total tank contains! Negative compartments show up in a different color than positive compartments to make them easier to identify. In most cases the tank can also be build using only positive compartments but is easier to create if negative compartments are used. This is shown on illustration 9.11 where two identical tanks are displayed. The green tank to the left is made out of 4 positive compartments while the blue tank is made out of only two compartments, 1 positive and one negative (dark red).

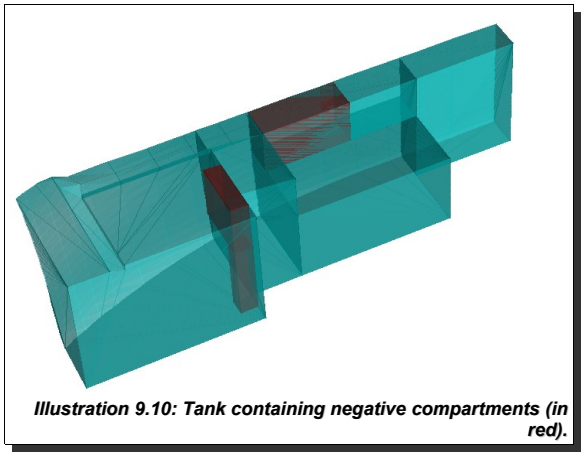


Illustration 9.10: Tank containing negative compartments (in red).

By using negative compartments it can sometimes be difficult to see the actual shape of the tank, especially if multiple negative compartments are used. By using only positive compartments this can be avoided as you always see the true shape of the tank.

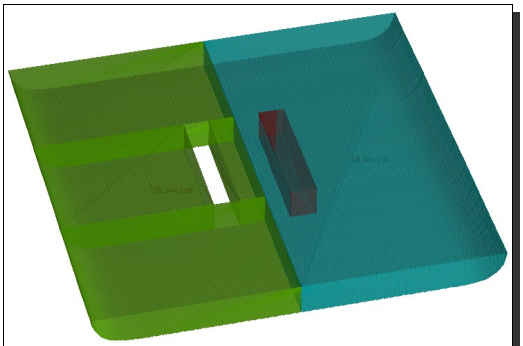


Illustration 9.11: Two identical tanks build in a different way.

9.2.2.4 Trim at hull

Normally compartments are automatically trimmed at the hull. If you don't want that you can disable this obtain and the compartment will have exactly the shape as defined in your input fields. This is especially useful if you want to define compartments in areas where no hull definition exists, for example when modeling the superstructure as a tank.

> If one of the input fields contains the value *shell* then the compartment is automatically trimmed at the shell and this option is disabled.

9.2.2.5 Use all layers

By default all layers are used whenever a compartment is being build. If you disable this option you'll be able to explicitly define what layers should be used for the selected compartment as described in paragraph 9.2.2.6.

9.2.2.6 Select

This enables you to select which layers should be used when the selected compartment is being build. As stated in paragraph 9.1 a compartment must be fully closed along all edges. By carefully excluding layers from the selecting sometimes errors can be avoided. Layers containing boundary edges can sometimes cause problems. Also it might be clear that layers that contain items such as sails, masts etc. should not be included in the selection.

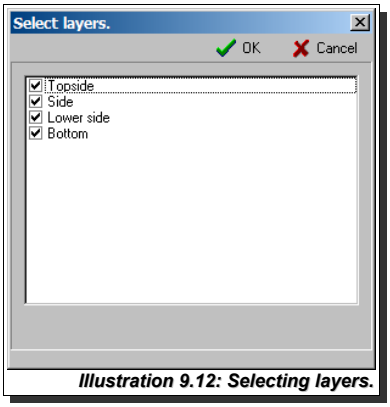


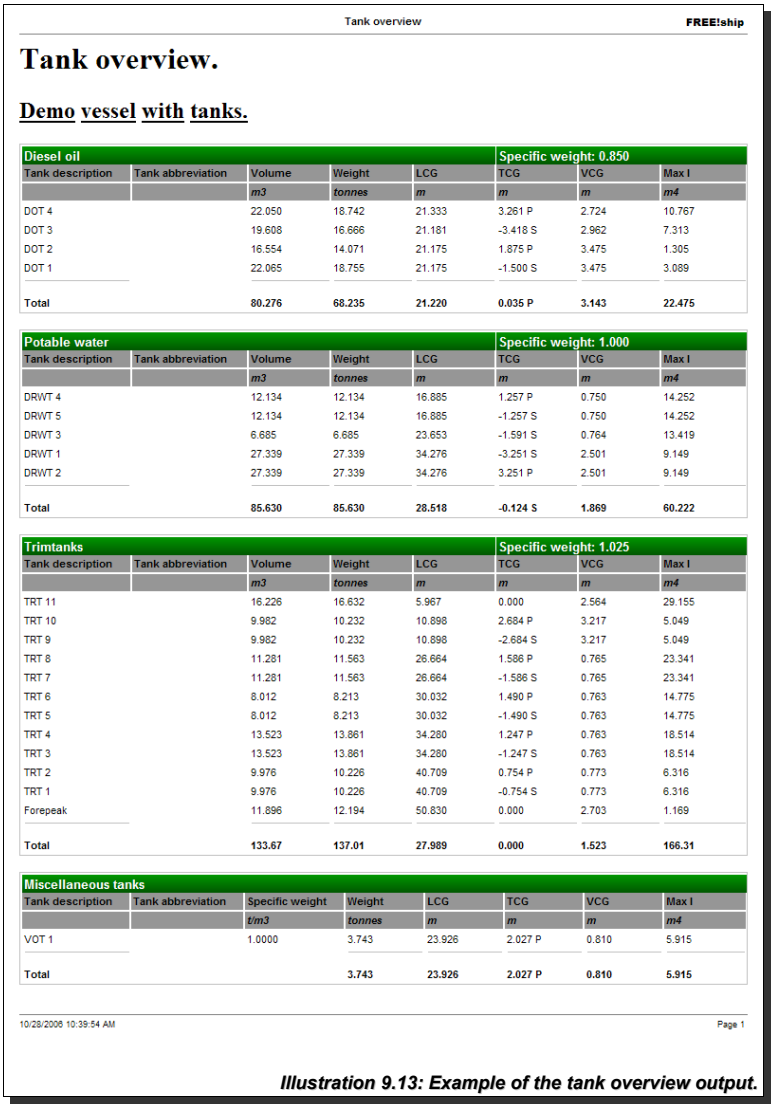
Illustration 9.12: Selecting layers.

9.2.3 Copy a tank or compartment

You can copy the selected tank or compartment by pressing the copy button on the toolbar.

9.3 Overview

Illustration 9.13 shows an example of the output that is produced by the tank overview option. Here you can clearly see the use of tankgroups as explained in paragraph 9.2.1.3. Tanks belonging to a tankgroup are grouped and presented in a separate table. First all tankgroups are presented and at the bottom a separate table is presented with tanks that are not assigned to a tankgroup.



Tank overview FREE!ship

Tank overview.

Demo vessel with tanks.

Diesel oil					Specific weight: 0.850		
Tank description	Tank abbreviation	Volume	Weight	LCG	TCG	VCG	Max I
		m3	*tonnes*	*m*	*m*	*m*	*m4*
DOT 4		22.050	18.742	21.333	3.261 P	2.724	10.767
DOT 3		19.608	16.666	21.181	-3.418 S	2.962	7.313
DOT 2		16.554	14.071	21.175	1.875 P	3.475	1.305
DOT 1		22.065	18.755	21.175	-1.500 S	3.475	3.089
Total		**80.276**	**68.235**	**21.220**	**0.035 P**	**3.143**	**22.475**

Potable water					Specific weight: 1.000		
Tank description	Tank abbreviation	Volume	Weight	LCG	TCG	VCG	Max I
		m3	*tonnes*	*m*	*m*	*m*	*m4*
DRWT 4		12.134	12.134	16.885	1.257 P	0.750	14.252
DRWT 5		12.134	12.134	16.885	-1.257 S	0.750	14.252
DRWT 3		6.685	6.685	23.653	-1.591 S	0.764	13.419
DRWT 1		27.339	27.339	34.276	-3.251 S	2.501	9.149
DRWT 2		27.339	27.339	34.276	3.251 P	2.501	9.149
Total		**85.630**	**85.630**	**28.518**	**-0.124 S**	**1.869**	**60.222**

Trimtanks					Specific weight: 1.025		
Tank description	Tank abbreviation	Volume	Weight	LCG	TCG	VCG	Max I
		m3	*tonnes*	*m*	*m*	*m*	*m4*
TRT 11		16.226	16.632	5.967	0.000	2.564	29.155
TRT 10		9.982	10.232	10.898	2.684 P	3.217	5.049
TRT 9		9.982	10.232	10.898	-2.684 S	3.217	5.049
TRT 8		11.281	11.563	26.664	1.586 P	0.765	23.341
TRT 7		11.281	11.563	26.664	-1.586 S	0.765	23.341
TRT 6		8.012	8.213	30.032	1.490 P	0.763	14.775
TRT 5		8.012	8.213	30.032	-1.490 S	0.763	14.775
TRT 4		13.523	13.861	34.280	1.247 P	0.763	18.514
TRT 3		13.523	13.861	34.280	-1.247 S	0.763	18.514
TRT 2		9.976	10.226	40.709	0.754 P	0.773	6.316
TRT 1		9.976	10.226	40.709	-0.754 S	0.773	6.316
Forepeak		11.896	12.194	50.830	0.000	2.703	1.169
Total		**133.67**	**137.01**	**27.989**	**0.000**	**1.523**	**166.31**

Miscellaneous tanks							
Tank description	Tank abbreviation	Specific weight	Weight	LCG	TCG	VCG	Max I
		t/m3	*tonnes*	*m*	*m*	*m*	*m4*
VOT 1		1.0000	3.743	23.926	2.027 P	0.810	5.915
Total			**3.743**	**23.926**	**2.027 P**	**0.810**	**5.915**

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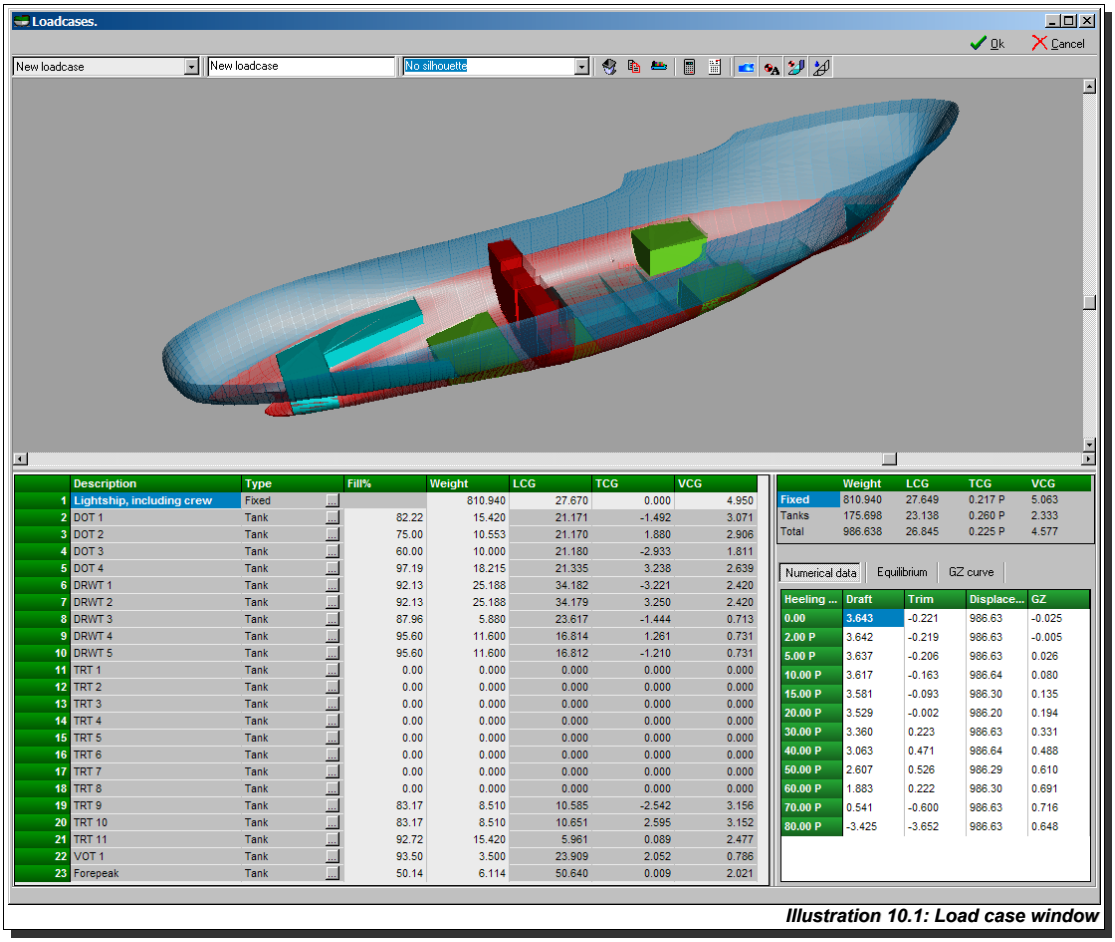
Illustration 9.13: Example of the tank overview output.

10. Load cases

10.1 General information about load cases.

A load case is in fact nothing but a collection of weights and related centers of gravity. These weights can be fixed (point) weights but also tanks that are (partially) filled. The sum of these weights equals the displacement of the ship. When the load case is being solved DELFTship tries to establish the position of the ship in the water for a number of heeling angles. Using this information the program calculates the draft, trim and heeling angle of the equilibrium state and also the stability curve. You can add as many load cases as you like. They show up in the drop down box left in the toolbar. You can select the appropriate load case from this list.

10.2 Edit



	Description	Type	Fill%	Weight	LCG	TCG	VCG
1	Lightship, including crew	Fixed		810.940	27.670	0.000	4.950
2	DOT 1	Tank	82.22	15.420	21.171	-1.492	3.071
3	DOT 2	Tank	75.00	10.553	21.170	1.880	2.906
4	DOT 3	Tank	60.00	10.000	21.180	-2.933	1.811
5	DOT 4	Tank	97.19	18.215	21.335	3.238	2.639
6	DRWT 1	Tank	92.13	25.188	34.182	-3.221	2.420
7	DRWT 2	Tank	92.13	25.188	34.179	3.250	2.420
8	DRWT 3	Tank	87.96	5.880	23.617	-1.444	0.713
9	DRWT 4	Tank	95.60	11.600	16.814	1.261	0.731
10	DRWT 5	Tank	95.60	11.600	16.812	-1.210	0.731
11	TRT 1	Tank	0.00	0.000	0.000	0.000	0.000
12	TRT 2	Tank	0.00	0.000	0.000	0.000	0.000
13	TRT 3	Tank	0.00	0.000	0.000	0.000	0.000
14	TRT 4	Tank	0.00	0.000	0.000	0.000	0.000
15	TRT 5	Tank	0.00	0.000	0.000	0.000	0.000
16	TRT 6	Tank	0.00	0.000	0.000	0.000	0.000
17	TRT 7	Tank	0.00	0.000	0.000	0.000	0.000
18	TRT 8	Tank	0.00	0.000	0.000	0.000	0.000
19	TRT 9	Tank	83.17	8.510	10.585	-2.542	3.156
20	TRT 10	Tank	83.17	8.510	10.651	2.595	3.152
21	TRT 11	Tank	92.72	15.420	5.961	0.089	2.477
22	VOT 1	Tank	93.50	3.500	23.909	2.052	0.786
23	Forepeak	Tank	50.14	6.114	50.640	0.009	2.021

	Weight	LCG	TCG	VCG
Fixed	810.940	27.649	0.217 P	5.063
Tanks	175.698	23.138	0.260 P	2.333
Total	986.638	26.845	0.225 P	4.577

Heeling ...	Draft	Trim	Displace...	GZ
0.00	3.643	-0.221	986.63	-0.025
2.00 P	3.642	-0.219	986.63	-0.005
5.00 P	3.637	-0.206	986.63	0.026
10.00 P	3.617	-0.163	986.64	0.080
15.00 P	3.581	-0.093	986.30	0.135
20.00 P	3.529	-0.002	986.20	0.194
30.00 P	3.360	0.223	986.63	0.331
40.00 P	3.063	0.471	986.64	0.488
50.00 P	2.607	0.526	986.29	0.610
60.00 P	1.883	0.222	986.30	0.691
70.00 P	0.541	-0.600	986.63	0.716
80.00 P	-3.425	-3.652	986.63	0.648

Illustration 10.1: Load case window

Illustration 10.1 shows the load case window. Weight items are displayed in the grid at the bottom. Only the contents of light gray cells can be modified. Dark gray cells are read only. The second column contains the description (or tank name) of each weight item The third column shows what type of weight it is. *Fixed* means it is a point weight while *tank* indicates that a tank has been assigned to this item. For fixed weights you have to specify both weight and center of gravity. For tank weights you can only set the desired weight or fill percentage. The actual fluid level and center of gravity is calculated by the program and can not be modified.

10.2.1 Add a new load case

By pressing the *new load case* button from the toolbar a new load case is added. By default it contains one weight item. Press the *insert* key to add more weight items or the *delete* key to delete a weight item. The order of weight items can be modified by selecting a weight item in the leftmost column and dragging it up or down to the desired position.

10.2.1.1 Modify the load case name

The name of the load case is displayed in the input field right next to the list with all load cases. The name of the load case can be modified in this box.

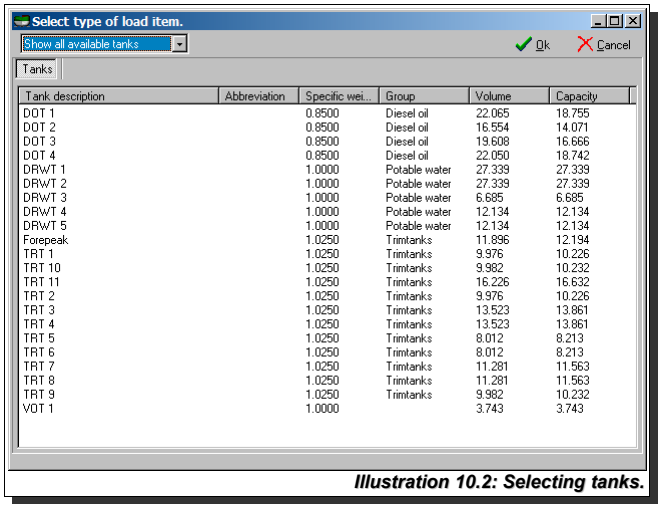
10.2.1.2 Selecting a windsilhouette

Next to the load case name there is a list that contains all the wind silhouettes that have been defined (see chapter 10.3). You can select one of these silhouettes and assign it to the active load case. The windmoment caused by this silhouette will be calculated and validated against the selected stability criteria.

10.2.1.3 Selecting a tank

By pressing the button in the third column a the windows from illustration 10.2 appears. Here you can select the tank that you want to assign to the selected weight item. The window has the option to display all available tanks or only tanks that have not been used in the current load case. Tanks are only allowed to be used once in each load case. You can also sort the displayed information by clicking the column headers. If no tank is selected and the OK button is pressed the weight item will be converted to a fixed weight type.

Load cases are always calculated with the actual center of gravity for each tank at each heeling angle and trim to compensate for any free surface effects.


Select type of load item.
Show all available tanks
Ok
Cancel
Tanks
Tank description | Abbreviation | Specific wei... | Group | Volume | Capacity
DOT 1 | 0.8500 | Diesel oil | 22.065 | 18.755
DOT 2 | 0.8500 | Diesel oil | 16.554 | 14.071
DOT 3 | 0.8500 | Diesel oil | 19.608 | 16.666
DOT 4 | 0.8500 | Diesel oil | 22.050 | 18.742
DRWT 1 | 1.0000 | Potable water | 27.339 | 27.339
DRWT 2 | 1.0000 | Potable water | 27.339 | 27.339
DRWT 3 | 1.0000 | Potable water | 6.685 | 6.685
DRWT 4 | 1.0000 | Potable water | 12.134 | 12.134
DRWT 5 | 1.0000 | Potable water | 12.134 | 12.134
Forepeak | 1.0250 | Trimtanks | 11.896 | 12.194
TRT 1 | 1.0250 | Trimtanks | 9.976 | 10.226
TRT 10 | 1.0250 | Trimtanks | 9.982 | 10.232
TRT 11 | 1.0250 | Trimtanks | 16.226 | 16.632
TRT 2 | 1.0250 | Trimtanks | 9.976 | 10.226
TRT 3 | 1.0250 | Trimtanks | 13.523 | 13.861
TRT 4 | 1.0250 | Trimtanks | 13.523 | 13.861
TRT 5 | 1.0250 | Trimtanks | 8.012 | 8.213
TRT 6 | 1.0250 | Trimtanks | 8.012 | 8.213
TRT 7 | 1.0250 | Trimtanks | 11.281 | 11.563
TRT 8 | 1.0250 | Trimtanks | 11.281 | 11.563
TRT 9 | 1.0250 | Trimtanks | 9.982 | 10.232
VOT 1 | 1.0000 | | 3.743 | 3.743
Illustration 10.2: Selecting tanks.

10.2.2 Delete a load case

You can delete the selected load case by pressing the button with the recycle bin from the toolbar.

10.2.3 Copy a load case

The copy option creates an exact copy of the currently selected load case.

10.2.4 Solve a load case

The solve button initiates the calculation procedure. Load cases that have been calculated but have been modified afterwards are automatically reset. After the load case has been solved and an equilibrium has been found the hull and weight items are drawn in the equilibrium state. The submerged surfaces are shaded accordingly.

10.2.5 Show report

You can only view the load case report if the load case has been solved. The short report (paragraph 4.5) only shows a summary of all the weight items while the extensive report displays also a summary for each individual tankgroup.

10.3 Wind silhouette

A wind silhouette is a graphical representation of the outer contour of the vessel which is used to determine the moment exerted by the wind on parts of the ship that are above the water. As shown on illustration 10.3 the windarea of cruiseships for example can be considerable.

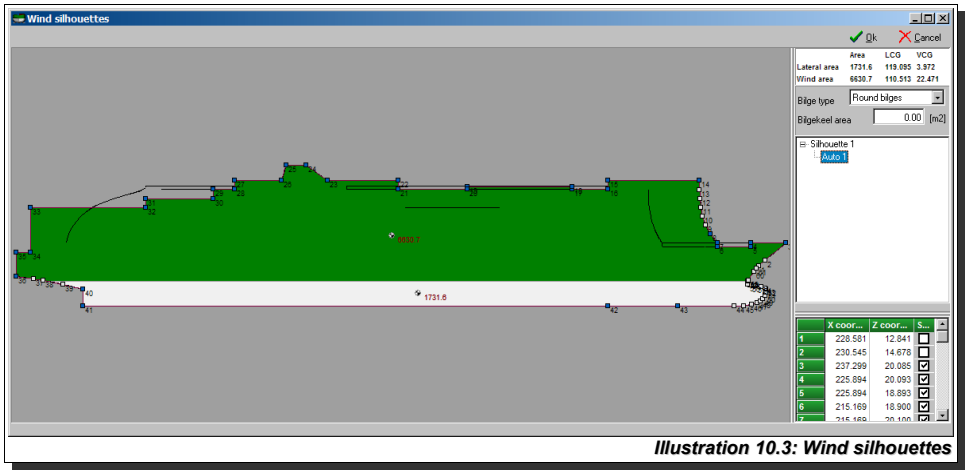


Illustration 10.3: Wind silhouettes

Another application would be to calculate sail areas or the lateral area and center of effort at various drafts.

Wind silhouettes can also be assigned to loadcases in which case the windmoment is validated against the selected stability criteria.

The right side of the input window can be subdivided into 3 different areas:

- The top area shows the main properties for the selected wind silhouette, such as wind area, lateral area, center of effort etc. You can also specify the area of bilgekeels here and the bilge type. This is only used to calculate the rollback angle for the standard IMO windcriterion as defined in the IMO A.749 resolution.
- The middle part contains a tree-structured list with all the wind silhouettes. Each silhouette may consist out of multiple sub-items, each one representing a closed contour. This way you may build up complex silhouettes, for example by modeling each sail of a sailing yacht as an individual sub-item.
- Below the list with silhouettes a grid is displayed that shows the coordinates of the currently selected sub-item. You can insert, delete or modify these coordinates manually but you can also drag the coordinates with the mouse on your screen.

10.3.1 Adding a new wind silhouette.

Make sure there no wind silhouette or sub-item is selected. You can do this by clicking on the white space in the list with wind silhouettes. Press the *Ins* key to insert a new wind silhouette or press the appropriate button on the toolbar. DELFTship automatically extracts a new silhouette from the current model. Usually if the model is not too complex it consists of a single sub-item. In other cases multiple sub-items can be generated. Some of these may be obsolete and should be deleted.

10.3.2 Modifying wind silhouette data

Once a wind silhouette is selected, the corresponding data is shown and can be modified. The bilgekeel area and type is only relevant for IMO stability criteria. The name of a wind silhouette can be modified by clicking on it with the mouse which causes the list to drop into editing mode. Once the *enter* key has been pressed the new name will be assigned to the wind silhouette. Altering the name of sub-items is done the same way. New sub-items are added by pressing the *ins* key on your keyboard. A selected sub-item (or wind silhouette) is deleted by pressing the *del* key. The coordinates of a selected sub-item are shown in the grid. Again coordinates are added or deleted by pressing the *ins* or *del* key.

10.4 Wind moment calculation

The wind moment calculation window shows a list with all the available wind silhouettes. You can select the appropriate silhouettes and specify a wind pressure. The default wind pressure is 51.4 kg/m^2 which is the standard IMO wind pressure for most vessels.

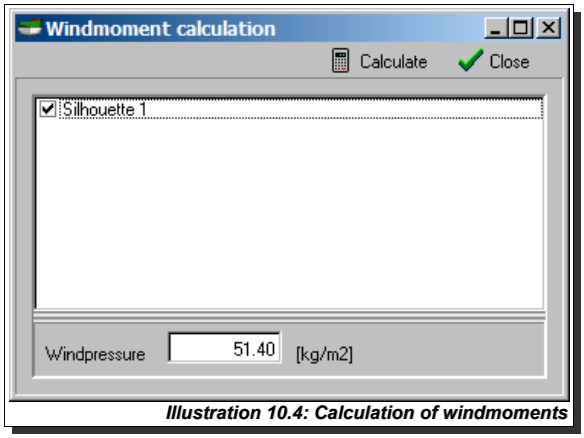


Illustration 10.4: Calculation of windmoments

11. View

11.1 Intersections

Intersection curves are calculated from the surface model. Only their location needs to be specified. Diagonals are always at an angle of 45 degrees to the center plane. Each time the model is modified the calculated intersection curves are rebuild. The buttons on the toolbar let you switch to which type of intersection you want to add or delete. You can add one intersection at a time by selecting the *+1* option in the menu. A window (illustration 11.1) is displayed asking for the location of the intersection. It is also possible to add a whole range at once by selecting the *+N* option. Only the spacing between successive intersection curves needs to be specified. The program starts at the origin (x=0, y=0 or z=0, depending on the type of intersection) and keeps adding intersection curves in positive and negative direction until the extents of the model is reached. The intersection curves appear in an increasing order of their distance. To delete an intersection, just select it and press the *delete* key on your keyboard.

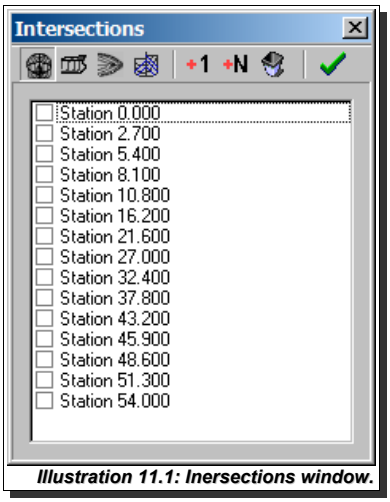


Illustration 11.1: Inersections window.

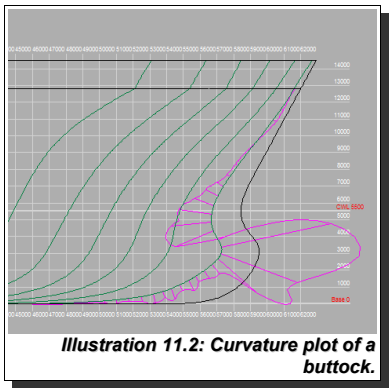


Illustration 11.2: Curvature plot of a buttock.

The checkbox displayed to the left of each intersection indicates if the curvature plot of that specific intersection curve must be plotted (see also paragraph 5.7.1) Due to the scale and nature of the computer screen it is in almost any case impossible to determine if a curve is fair. To overcome this a curvature plot is often drawn. A curvature plot means that in a large number of points of a curve the curvature is calculated and plotted perpendicular to the curve (the purple line). Since the curvature can be positive as well as negative, the plot can swap from one side of the curve to the other (illustration 11.2). Where the plot intersects the curve the curvature is zero. So in areas of a curve where the curvature is zero (straight line segments), both curves are drawn on top of each other. At a knuckle point on the other hand the curvature is infinitely high. So the higher the absolute value of the curvature, the further the curvature plot is drawn away from the curve. Smooth curves are characterized by curvature plots with no unexpected humps or hollows, the curvature must change gradually as is the case with the waterline below. The scale of the curvature plot can be decreased by pressing the F9 key and increased by pressing the F10 key. Make sure that the curvature plot is switched on in you the display settings.

11.2 Linesplan

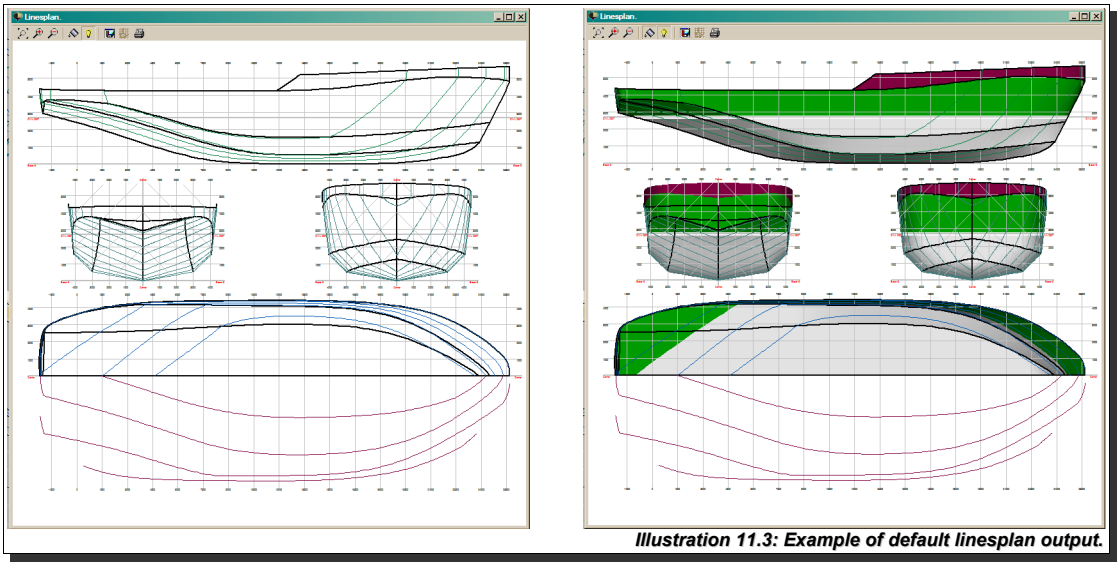


Illustration 11.3: Example of default linesplan output.

DELFTship enables the user to view the complete formatted linesplan of the ship. This can be done in two different modes, wireframe mode (to the left) and the filled mode (to the right). The linesplan shows all the intersection curves, regardless of the display settings of the corresponding intersection curves. So stations are always shown in the linesplan, even if they are switched off in the display settings. Currently this linesplan can be saved as a bitmap, to a dxf file, or sent directly to the printer/plotter. The linesplan can also be drawn in black & white by clicking on the appropriate button in the toolbar. Using fill colors is not possible in black & white mode. Only if the model contains no diagonals, the plan view might optionally be mirrored so that both sides are visible. Some layers can be hidden from the linesplan. How this is done is described in paragraph 5.8.1.

11.3 Design hydrostatics

A simple hydrostatic calculation is performed of the ship at the design draft, as specified in the project settings (paragraph 4.2). The way coefficients are calculated and how to modify this is explained in paragraph 4.3. The report shows not only hydrostatic values but also the surface area and center of gravity for each layer. All properties are calculated for the entire ship. If the model contains stations then the sectional area curve is also plotted.

Hydrostatics report DELFTship

Hydrostatics report.

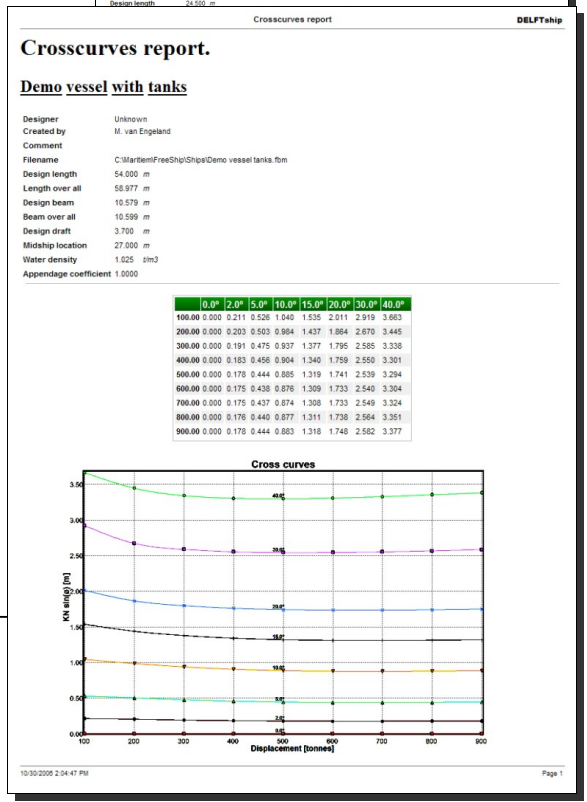
Demo tug

Designer
Created by Marven
Comment Demo tug used in the FREEship manual Displ. 283 t.
Filename C:\Maritiem\FreeShip\Ships\Database\FREEship demo tug.fbm
Design length 24.500 m

If imperial units are used, the displacement is given in longtons (1 long ton equals 2240 lbs).

11.4 Hydrostatics

This option is used to perform hydrostatic calculations at a range of drafts. One trim may also be specified. The report can be printed or the results saved to a HTML file. Illustration 11.4 shows an example of the produced output.


Crosscurves report DELFTship

Crosscurves report.

Demo vessel with tanks

Designer Unknown
Created by M. van Engeland
Comment
Filename C:\Maritiem\FreeShip\Ships\Demo vessel tanks.fbm
Design length 54.000 m
Length over all 58.977 m
Design beam 10.579 m
Beam over all 10.599 m
Design draft 3.700 m
Midship location 27.000 m
Water density 1.025 t/m3
Appendage coefficient 1.0000

	0.0°	2.0°	5.0°	10.0°	15.0°	20.0°	30.0°	40.0°
100.00	0.000	0.211	0.526	1.040	1.535	2.011	2.919	3.663
200.00	0.000	0.203	0.503	0.984	1.437	1.864	2.670	3.445
300.00	0.000	0.191	0.475	0.937	1.377	1.795	2.585	3.338
400.00	0.000	0.183	0.456	0.904	1.340	1.759	2.550	3.301
500.00	0.000	0.178	0.444	0.885	1.319	1.741	2.539	3.294
600.00	0.000	0.175	0.438	0.876	1.309	1.733	2.540	3.304
700.00	0.000	0.175	0.437	0.874	1.308	1.733	2.549	3.324
800.00	0.000	0.176	0.440	0.877	1.311	1.738	2.564	3.351
900.00	0.000	0.178	0.444	0.883	1.318	1.748	2.582	3.377

Cross curves

KN sin(φ) [m]

Displacement [tonnes]

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11.5 Crosscurves

Stability calculations are also provided in the form of cross curves. For a number of heeling angles and displacements

KN*sin(ø) is calculated and presented in both graphical and tabular form. If only one single displacement is specified KN*sin(ø) curve is displayed. If multiple displacements are provided the graph shows the standard cross curves. The crosscurves are calculated while the hull is free to trim. For each displacement the calculation is started with a level trim (trim=0.0) and then for each heeling angle the trim is adjusted to maintain a constant center of buoyancy. If the critical points module has been purchased the report also contains an downflooding overview. For each heeling angle the first submerged downflooding point is displayed and the corresponding displacement.

11.6 Plate developments

All layers which are marked as developable in the layer properties window (paragraph 5.8.6) are unfolded onto flat plates (a process also called developing). If the model contains no developable layers then this option appears disabled. Both sides of the ship are unfolded. A window then appears showing the plate developments. It is best to assign each strake or part of the hull to a different layer. Then each layer will have its own unfolding. If a layer consists of multiple separate parts, each part again will have its own unfolding. The unfolded panels can be moved by dragging them with the mouse. Buttons on the toolbar at the top of the window can be used to rotate the currently selected item. The rotation angle of each panel may also be

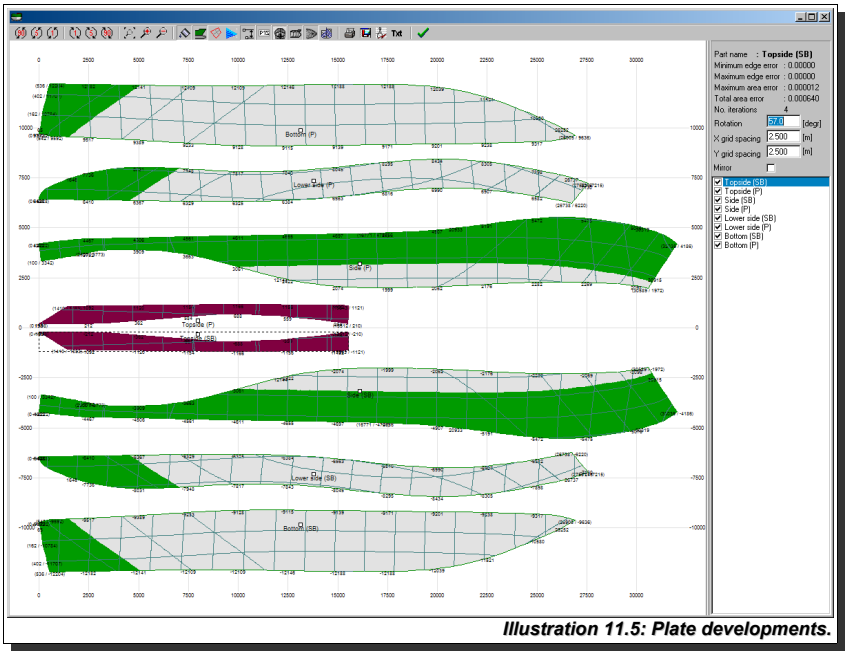

Illustration 11.5: Plate developments.

entered manually. Zooming and panning can be done exactly as in the windows used for modeling the ship. Interior edges and any present intersection curves are also drawn on the unfolded panels, and can be switched on or off as desired. The initial settings for these options are the same as those of the display settings for the entire model. So if the stations are turned off in the hullform windows, they will not show on your plate developments either, until they are turned on again. The viewport be can saved as a bitmap, but visible plate developments can also be exported to a .dxf file or sent directly to the printer/plotter. The coordinates forming the boundary of each part can be exported to an ASCII text file.

On the right of the window a list is visible, showing all unfolded parts. By clicking on the check boxes each plate development can be made visible or invisible. At the top some crucial information about the developments is shown. After the plates have been unfolded to 2D, DELFTship compares the length of the unfolded interior edges to the length of these edges in 3D. If this length is smaller then the edges were compressed (drawn in blue). If the unfolded edges are longer then these edges were stretched (drawn in red). The minimum error shown at the top is the largest compression error that occurred (in world space dimensions, so meters or feet). The maximum error is the largest amount of stress of an edge. Compressed or stretched edges may be visualized by turning both the visibility of interior edges and highlighting of compressed edges on. The difference in area between the 3D surface and the unfolded surface is also shown. Below the displayed edges the number of iterations it took to unfold the selected panel is shown. DELFTship makes up to 25 developments of each panel and uses the one with the smallest overall error as the final one. Generally surfaces that are truly developable are unfolded in 1 iteration, and have min. and max. errors of 0.0. Surfaces that are not exactly developable can in most cases still be unfolded but might have significant errors due to the fact that the surface is curved in two directions. Think of it as the top half of a sphere, you can not press this surface down to a flat surface without stretching or compressing certain areas, unless you make some cuts of course. So it's **very important** to check these errors when you actually want to use the unfolded plates for construction purposes!

There are also two input fields to adapt the grid spacing. The grid can be turned on and off from the toolbar. Each intersection of a grid line and an unfolded panel has a number next to it indicating the coordinate of that intersection.

The two panels that are created from layers that border the center plane of the hull and are completely flat, such as for example a flat transom or bottom, are merged into 1 unfolded panel.

11.7 Resistance

11.7.1 Delft series

The Delft series resistance calculation is a method that is intended for fin-keeled yachts. It's a statistical method based upon a whole series of models that are tested over the years in the towing tank of the Delft University of Technology. The calculation is not restricted to models that are in the same range as those of the tested models. Results of models that are outside the range however can be quite off with sometimes even negative results for the residual resistance.

These ranges are:

- ✔ Lwl/Bwl : [2.76 - 5.00]
- ✔ Bwl/Thull : [2.46 - 19.32]
- ✔ $Lwl/Displ^{0.333}$: [4.34 – 8.50]
- ✔ LCB (in % of Lwl) : [-6.0 – 0.0]
- ✔ Cp : [0.52 – 0.60]

There are two different ways to use the module:

- Fill in all the data manually. You don't even need a hull to do this. Each time a modification is made everything is recalculated and updated.
- Let the program calculate the hydrostatic values that are needed by clicking on the checkbox that says: "*Extract data from current hull*". Only two input fields concerning the hull data are enabled in this mode. One is for the draft of the hull alone, the other for the total draft of the hull including the keel. This last draft is used when the hydrostatic values are calculated, assuming you have indeed attached a keel at the bottom of the hull. If this is not the case, then fill in the draft of the hull alone as if it was

the total draft including the keel. As all data has been calculated by the program then disable the "*Extract data from current hull*" checkbox, and set the correct drafts in the two edit fields and continue as normal.

All data used for the resistance calculation is stored with the model.

11.7.2 Kaper

The KAPER resistance method is intended for canoes and kayaks. It was originally developed by John Winters, a naval architect now specializing in designing canoes and kayaks. (See http://www.greenval.com/jwinters.html) It is based on statistical data obtained by model tests. His method is later extended by Matt Broze to higher speed/length ratios and to incorporate more variables into the equations. This extended version is available in the form of an Excel spreadsheet from http://www.marinerkayaks.com/mkhtml/downloads.htm. However while implementing this method in DELFTship two serious discontinuities showed up in the curve of residual resistance. These consist of a sudden drop in resistance of about 10% at speed/length ratios of 1.4 and 1.6 and are the result of a correction implemented by Matt. After careful consideration the decision was made to only allow calculations up to a speed/length ratio of 1.4 in order not to give the user a false sense of security. It also restricts the method to stay within the range of parameters of the actually tested hulls.

Basically there are two ways to use the KAPER resistance method. The easiest way is to open it with a design in memory. In that case the checkbox saying "*extract data from the current hull*" is enabled and may be checked. If it is checked all input fields, except those for the draft and submerged transom ratio, are disabled. When the draft is changed the program calculates the appropriate hydrostatics corresponding to that draft and the resistance data is updated. The other way is by removing the check from the checkbox. In that case you can specify (or modify after most values have been automatically calculated) all input values manually.

After each modification the resistance is recalculated. You can see the data either graphically on the first tab page or numerically on the second tab page. The range of valid parameters is:

- Prismatic coefficient 0.48-0.64
- Submerged transom ratio 0.0-0.04
- None of the other variables other than the waterline entrance angle is allowed to be zero.

The graph displays 4 resistance curves. The first three are for frictional resistance, residual resistance and the total resistance. The fourth line is showing the total resistance according to Spilman. The residual resistance in this case is a very simple formula based only upon the speed/length ratio of the design and is included to give the user a point of reference.

All data entered in the input fields of this resistance method is also stored in the DELFTship file.

The center of buoyancy used in the Kaper method is measured from the bow and made dimensionless by dividing the distance by the waterline length.

12. Selection

12.1 Selecting objects in DELFTship

Selecting objects in DELFTship is pretty straightforward. Almost any visible object in the hull modeling windows can be selected by clicking on it with the mouse. Clicking it again will deselect it. Only critical points (paragraph 4.4) can not be selected this way. Selecting works only when the windows are in the wireframe mode (shading must be turned off). Selected objects are drawn in yellow.

For some objects there are some additional ways of selecting which can make life easier:

- **Points.** If a point is selected, and the user clicks on a different point, this new point will be selected and the previous point will be deselected. Selecting multiple points however is possible by keeping the CTRL-key pressed while selecting the new point.
- **Edges.** If the CTRL key is pressed while an edge is being selected, the program tries to trace the edge until a irregular point is encountered or an edge with a different crease-property. This way it is easy to select an entire row of edges (edge loop) such as for example the sheerline or a hard chine.
- **Faces.** Faces also can be CTRL-selected. In that case all the faces belonging to the same layer and connected to the selected one are also selected or deselected. Faces that are isolated from the selected face because they are totally surrounded by crease edges are not included.

12.2 Select all

With this command (also available by pressing the shortcut Ctrl-A) all visible objects are automatically selected.

12.3 Deselect all

Use this option to deselect all selected items simultaneously. Pressing the Esc-key has the same result.

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